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Novel Use of Mobile and Ubiquitous Technologies in Everyday Teaching and Learning Practices: A Complex Picture

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Novel Use of Mobile and Ubiquitous Technologies in Everyday Teaching and Learning Practices: A Complex Picture

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To my mother
and father

Abstract

As of autumn 2011, all schools in Sweden have adopted and applied the latest curriculum for the compulsory school system. The following is written in concern to technology:

> *The school is responsible for ensuring that each pupil on completing compulsory school: […] can use modern technology as a tool in the search for knowledge, communication, creativity and learning. (Skolverket, 2011, pp.13-14)*

With this said, there are no guidelines or manuals on how this is to be conducted. In a report from the Swedish Schools Inspectorate it was concluded that the investment in technology is not being used for school education. The education systems keep investing in technology in the belief that schools and teachers will sooner or later adopt and benefit from the use of mobile and ubiquitous technologies.

The aim of this study is to "*create an understanding of the aspects that have an impact on adopting novel use of mobile and ubiquitous technologies in everyday teaching and learning practices in compulsory schools*."

The empirical foundation will be based upon three projects: Geometry Mobile (GeM); Learning Ecology with Technologies from Science for Global Outcomes (LETS GO); and Collaborative Learning Using Digital Pens and Interactive Whiteboards (Collboard). All were conducted at local compulsory schools in Växjö municipality, Sweden, in collaboration with teachers, students and fellow researchers from the CeLeKT research group at Linnaeus University.

Two Thematic Analyses have been conducted: the first, an inductive analysis exploring the Students' and Teachers' Experience of using Mobile and Ubiquitous Technologies in their learning and teaching environment. The second analysis is deductive and uses themes from the Unified Theory of Acceptance and Use of Technology models with the aim of understanding the Perception and Acceptance of Teachers' use of Mobile and Ubiquitous Technologies. In the results from the two analyses there are clear indicators on the added value that mobile and ubiquitous technology brings to the classrooms: students are able to actively participate, collaborate and discuss in different learning settings, which enhances their understanding of the subject at hand. The challenges are mainly to be found in the lack of training and education in use of the technology as a supporting tool for teaching and learning. Further factors influencing the teachers and the students are ease of use and reliability of the technology and societal changes.

The results of the analysis and the theoretical base of Technology Enhanced Learning have been illustrated with Soft Systems Methodologies Rich Picture, providing a holistic view of the problematic situation and making it possible to discuss the various parts as well as the situation as a whole. This study indicates that there are several factors influencing the adoption of the novel use of mobile and ubiquitous technologies in everyday teaching and learning within a complex situation on different levels.

Keywords: mobile and ubiquitous technology; novel use; technology enhanced learning; rich pictures; soft systems methodology; thematic analysis; unified theory of acceptance and use of technology; compulsory school in Sweden

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Sadaf Salavati

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CHAPTER 1

Introduction

"I hear and I forget, I see and I believe, I do and I understand"
Confucius (551-497 BC)

Over 40 years ago, Alan C. Kay at Xerox Palo Alto Research Centre envisioned a personal computer for children (Kay, 1972; Kay & Goldberg, 1977). The Dynabook was described as a dynamic medium for creative thought, a knowledge manipulating device as small as a notebook with the power to exceed the human senses. Kay and Goldberg (1977) mention different ways in which the Dynabook could be used: e.g. an architect able to simulate three-dimensional spaces in order to pursue and edit her/his design; a business employee having an active portfolio containing records, accounts, budgets, etc. which can be taken with her/him anywhere, and for the educators a new world of possibilities, limited only by the imagination (Kay & Goldberg, 1977). The wonderful, much-loved physical book has made it possible for humans to gain and distribute knowledge for centuries. However, as Kay (1972) claims, technology can provide us with a "better book" that, just like its users, is more active and can also contribute to the creation and development of knowledge (Kay, 1972).

The history of computing since Kay, and even earlier, has evolved and developed in directions unimaginable for many. The evolution of computing has gone from one computer per many users in the Mainframe Era of 1960s to the Mobility Era of 2000s with several computers per user and, predicted for the 2020s and beyond, to reach the Ubiquity Era with thousands of computers per user (Harper et al., 2008, pp. 14-15). The impact that mobile and ubiquitous technologies have had on society have brought changes in all aspects of our lives. Technologies are influencing and becoming a part of our everyday living (Ladyman, 2002; Bradley, 2006b; Harper et al., 2008; Pachler et al., 2010). Clothing manufacturers are exploring and experimenting with the use of Bluetooth technologies in, for instance, running shoes that enable interaction through mobile devices that provide information about the speed of the runner, how far they have been running, help updating training logs, etc. In medicine, medical devices are being developed that can be worn on the body providing

instant reports and alerts on the status of various bodily functions, such as cholesterol or glucose levels (Harper et al., 2008).

In today's society the evolution of the Internet has enabled more contact with family members and friends, accessing all kind of information, entertainment, and making possible all sorts of errands online (Lebo et al., 2012). Mobile phones have been the most ubiquitous form of computing and technology where these devices have become much more than simple phone-call devices. The size of the phones has reduced while the potential has increased, allowing connection with others in new ways as well as access to information and interactions with other objects in our daily lives. Harper et al. (2008, p. 19) argue that the mobile phone acts as an "extension of our own hands." Such technological developments, have changed family life and even the process of growing old. It is now possible, for example, to keep in touch, socialize and keep track at all times of children and loved ones; maintain medical support; and use memory aids for the elderly (Bradley, 2006a; Harper et al., 2008; Lebo et al., 2012). Governments are now able reach out and inform its citizens as well as gather information about them in a wider but also more complex way (Harper et al., 2008). The structure of organizations, the work process, tasks and their performance have altered due to the rapid development and increasing influence of technologies (Bradley, 2006a; 2006b). Mobile and ubiquitous technologies no longer belong just to the privileged; now, an inexpensive, everyday commodity is changing and filling our private-, public-, and professional lives (Bradley, 2006a; 2006b; Harper et al., 2008; Lebo et al., 2012).

Despite the changes in society and extensive availability of computers, laptops, and smart phones, is school education, as argued by Patcher et al. (2010) and Gruffin et al., (2012a), still conducted in the same way as a few decades ago. Gärdenfors (2010) quotes Howard Gardner's opinion that if a person from the twentieth century were to come to our society they would very much recognize themself in today's classrooms. The broad image of the school classroom today is based on the traditional setting: a fixed location with a single, trained teacher mediating, a set of resources, and a pre-decided curriculum that needs to be followed from day to day, containing principles for a common ground and stabile context (Sharples et al., 2007). The students are taught to work individually in order to recall and spill out facts they have learned by solving pre-defined problems within narrowly-defined school subjects (Griffin et al., 2012a). Schools, which are responsible for the formal education of future generations, are the only institutions beside the church that have changed very little (Gärdenfors, 2010). It is mentioned by many researchers that the educational system is challenged from many different perspectives (Dillenbourg et al., 2009; Gärdenfors, 2010; Pachler et al., 2010; Scardamalia et al., 2010; Griffin et al., 2012b). Pachler et al. (2010) foresee a danger in the educational systems being unable to keep up with the changes and developments of society and the everyday world of the young people.

In a technology- and knowledge-dependent society, Scardamalia et al. (2010) argue that literacy is the most crucial skill. They believe anyone not having the ability to extract and contribute useful information from various complex sources such as texts, graphics and other representations will fail to qualify for the knowledge society (Scardamalia et al., 2010).

On the webpage of the European Commission's Digital Agenda for Europe, under the headline Digital Life and Education, it is written that in the coming years 90 per cent of all jobs will require digital skills. In our society the demand for highly-skilled ICT workers is increasing by 3 per cent a year. The European Commission argues that "what reading and writing are to today's labour market, digital literacy is to tomorrow's" (European Commission's Digital Agenda for Europe[1], 2012). It is a crucial requirement to prepare

[1] Digital Agenda for Europe, Digital Life http://ec.europa.eu/digital-agenda/node/1104 accessed: 2012-11-27

learners to face twenty-first century society. Youngsters can gain some of these skills on their own through daily life, although these skills need to be in education as this could determine which young people will be successful and which ones will be left behind (Jenkins, 2009).

In the latest Swedish School Act (SFS, 2010:800) and national curriculum for compulsory school, preschool and leisure-time centre (Skolverket[2], 2011) it is clearly stated that technology should be part of the education as students should have access to an up-to-date education and be able to use "modern technology." The Swedish Government, in the national IT policy, has stated that teachers should and students must have access to technology that is essential for contemporary education (Näringsdepartementet[3], 2011). However, this is not always the case. In many cases the technology is used for administrative work and in a very limited way in teaching and learning. During the last couple of years the availability of technology in school classrooms has greatly increased but, apart from that, not much has changed. The technology is still used in a very limited way, and only in some subjects (Skolinspektionen[4], 2012; Skolverket, 2012; Skolverket, 2013).

From the Swedish National Agency for Education, Thullberg and Szekley (2009) argue that many teachers believe their lack of good IT competence to be one reason why they do not use technology in their teaching. This lack of knowledge and confidence can also be seen in the teacher training programs (Thullberg & Szekley, 2009). Prospective teachers and teacher educators are far from being at the cutting edge when it comes to use of technology in educational practices (CMA, 2009). This is also mentioned by Gärdenfors (2010) who claims that the majority of teachers do not have sufficient knowledge and understanding of how technology can add value to the classroom. He further argues that it is not enough to just equip schools with computers, it is also important to be able to use the computers in a purposeful and reasonable way (Gärdenfors, 2010, p. 224). Thullberg and Szekley (2009) further state that there is a lack of strategies and discussions on possibilities and restrictions with ICTs in educational settings: there is need for a long-term plan on how to integrate mobile and ubiquitous technologies into the daily pedagogy. Scardamalia et al. (2010) argue that the teachers are too often left on their own to figure out how to bring in and integrate technology in their curricular and learning activities. The schools are covering up their insufficient technology-enhanced pedagogics by just equipping themselves with computers and other technological equipment (Gärdenfors, 2010, p. 224).

In a report given by the Organisation for Economic Co-operation and Development[5] (OECD) in 2010 it is stated that the education systems keep investing in technology with the belief that schools and teachers will sooner or later adopt it and benefit from the use of it (OECD, 2010). OECD further reports that in most OECD countries teachers' access to technology or lack of required basic technical skills is no longer the reason why teachers have not embraced and adopted mobile and ubiquitous technologies. They argue that, on the contrary, many teachers are aware and convinced of the benefits that technology can bring to an educational setting. The report states three challenges why teachers have not found a feasible approach to integrating and using technology in school education: *Knowledge base* which argues that there is a poorly-addressed connection between pedagogy and practices involving the technology and its effects on quality, justness and performance; *Teacher training*

[2] National Agency for Education in Swedish

[3] Ministry of Industry, Employment and Communications in Swedish

[4] The Swedish School Inspectorate in Swedish

[5] A forum where governments work together to address the economic, social and environmental challenges of globalization. Member countries consist of 34 countries all around the world among others, the Scandinavian counties. More information could be retrieved from: http://www.oecd.org/about/membersandpartners/

argues most teacher training colleges are unable to provide prospective teachers real hands-on experiences in technology-enhanced pedagogies, and hence fails to give them the qualifications and requirements to effectively use technology in the classroom. These crucial institutions seem to have a rather reluctant attitude towards technology. The final challenge is referred to as *Incentives* that talk of the importance of a greater effort by teachers collectively and individually in order to enable a pedagogical change, but without any supporting guidelines or rewards for the required effort (OECD, 2010, p. 17).

As mentioned above, schools and educational systems invest in computers and technologies although Christensen et al. (2008) argue that this is done in a predictable and logical way which, for the educational system, is the wrong way as these technologies have not always been designed or developed to suit educational purposes and is thus usually not used to its full potential (Christensen et al., 2008; Laurillard, 2009; Pachler et al., 2010). Each organization needs to modify and shape new innovation to fit the organization at hand and the question to address is how these innovative technologies and their use can bring added value to the traditional educational settings and to make it sustainable (Christensen et al., 2008).

Despite the political, organizational and individual efforts and perceptions of the novel use of mobile and ubiquitous technologies to support everyday teaching and learning, students will bring the technology into their schools (Scardamalia et al., 2010). In a report for NESTA Futurelab, Naismith et al. (2004) concluded that, whether technology and specifically mobile devices are welcomed or not in educational settings, they will find their ways into the classrooms through the children.

1.1 Research Purpose and Question

It can be argued that twenty-first century society is influencing and being influenced by mobile and ubiquitous technologies and, for the younger generation to be successful, there is the need for a new set of literacies as well as for educational systems to connect to their learners' everyday lives. It is also clear that there are investments in bringing in technology into educational settings, but the technology is not always used to its full potential (Pachler et al. 2010; Skolinspektionen, 2012) and, as reported by the OECD, there is still not enough known about the connection between the research findings, public policies and educational innovations even if the role of research evidence has increased in policy formation for education (OECD, 2010, p.17).

Many Swedish schools today are equipped with various technologies, although these technologies are mainly used as administrative tools and only used in a limited way to support everyday teaching and learning practices (Skolverket, 2012). In the latest Swedish Governmental IT policy, the newest School Act from 2010, and the curriculum adopted since fall 2011, the use and importance of "modern technologies" and "modern learning tools" in compulsory education is clearly stated (SFS, 2010:800; Näringsdepartementet, 2011; Skolverket, 2011). What is lacking are strategies, guidelines and educational support on how this is to be conveyed and adopted, hence mobile and ubiquitous technologies now only have limited use and obstruct the pedagogical work, even if there is interest and ambition for its adoption and use (Thullberg & Szekley, 2009; Skolinspektionen, 2012).

Educational practice is highly complex, and consists of several factors and conditions to consider. According to Dewey (1929), no scientific conclusion can be straightforwardly converted and implemented in educational practices. The importance of one factor within

the educational practice can only be verified when it is in balance with many other factors (Dewey, 1929).

Hence, the aim is to *create an understanding of the aspects that have an impact on adopting novel use of mobile and ubiquitous technologies in everyday teaching and learning practices in compulsory schools.*

The term novel[6] in this thesis is concerned with new, interesting and unique ways of using technology, while the concept of adoption[7] is about taking up and starting to use an idea, to embrace, approve and accept something. To create an understanding of what induces the teachers and students to adopt and use mobile and ubiquitous technologies in novel ways, the following research questions are addressed:

- *What factors influence the novel use of mobile and ubiquitous technologies to support teaching and learning practices?*
- *What opportunities do mobile and ubiquitous technologies bring to a learning environment?*
- *What are the challenges?*

However, with the aim and research questions stated above, this study does not argue for the replacement of traditional education but, rather, to build upon the educational practice which has been successful for centuries. As will be stated later in this thesis, education can be conducted without the use of mobile and ubiquitous technologies, although such technologies can bring other dimensions to teaching and learning. This, together with new opportunities and possibilities, will be addressed thought this thesis in answering the research questions above.

1.2 Research Scope and Limitations

The research is located within the field of Technology Enhanced Learning, TEL. The field consists of several directly- and indirectly-related and influential areas and disciplines, e.g. pedagogy, design, software-/hardware development, etc. Kurti (2009) talks of three challenges within TEL; technology and engineering, design and interaction, and learning, social and cognitive[8]. This thesis will touch upon these challenges mentioned by Kurti (2009) but without going into them in great detail. This study will mainly cover the relation between the challenges and how these and other potential challenges relate and integrate with one another within the whole area of TEL.

The focus will be on compulsory school level. Further, teacher training programs and education will not be included, although, as one of the projects involves students studying to become teachers, their viewpoint and experiences will be briefly mentioned.

The core of this study is based on three projects (see Chapter 3) conducted with local schools in Växjö, Kronoberg municipality, Sweden. The projects are: GeM, a mathematics project using mobile devices to create opportunities for collaboration and discussion

[6] Novel is defined as "new or unusual in an interesting way" (Oxford Dictionaries, 2010, http://oxforddictionaries.com/definition/american_english/novel--2, accessed February 26, 2013)

[7] Adopt is defined as "take up or start to follow (an idea, method, or course of action)" and "formally approve or accept" (Oxford Dictionaries, April 2010, http://oxforddictionaries.com/definition/american_english/adopt, accessed February 26, 2013).

[8] These will be further presented in Chapter 2.2

in outdoor settings; LETS GO, the second project, uses sensors, mobile technology and wireless Internet to support students in their learning about ecology in nature; the third project, Collboard is a mathematics project focusing on New Media Literacies[9] using digital pens and interactive whiteboards in a classroom setting.

1.3 Thesis Overview

The rest of the thesis is as follows (see also Figure 1.1):

Chapter 2 presents and briefly describes the role of technology in today's society and the discipline of Technology Enhanced Learning including New Literacies and 21st Century Skills. Two research projects within TEL from different countries are presented that use mobile and ubiquitous technologies in novel ways.

Chapter 3 presents the research settings, giving account of the projects upon which the empirical work is based, and a brief overview of the public policies addressing technology in education in Sweden. Further the methods of data collection, the thematic analysis and ethical considerations are presented.

Chapter 4 describes the analysis methods applied in order to answer the study's questions. The Deductive Thematic Analysis (Unified Theory of Acceptance and Use of Technology), and Soft Systems Methodology are presented and discussed.

Chapter 5 presents the results of the empirical analysis, giving an account of how the use of technology is experienced by the participants, based on the inductive thematic analysis and the perception and acceptance of the teachers based on the deductive thematic analysis.

Chapter 6 brings together the issues from Chapters 1, 2 and 3 with the results of the analyses from Chapter 5, using Soft Systems Methodology, specifically Rich Pictures to illustrate the situation based on the aim and research questions of the thesis

Chapter 7 states the conclusions of the thesis as well as reflects upon the research method, methodologies and research approaches.

Chapter 8 concludes the thesis by presenting the contribution to the theory and to the field of TEL, and future work.

[9] New Media Literacies will be further explained in Chapter 2.3 New Literacies

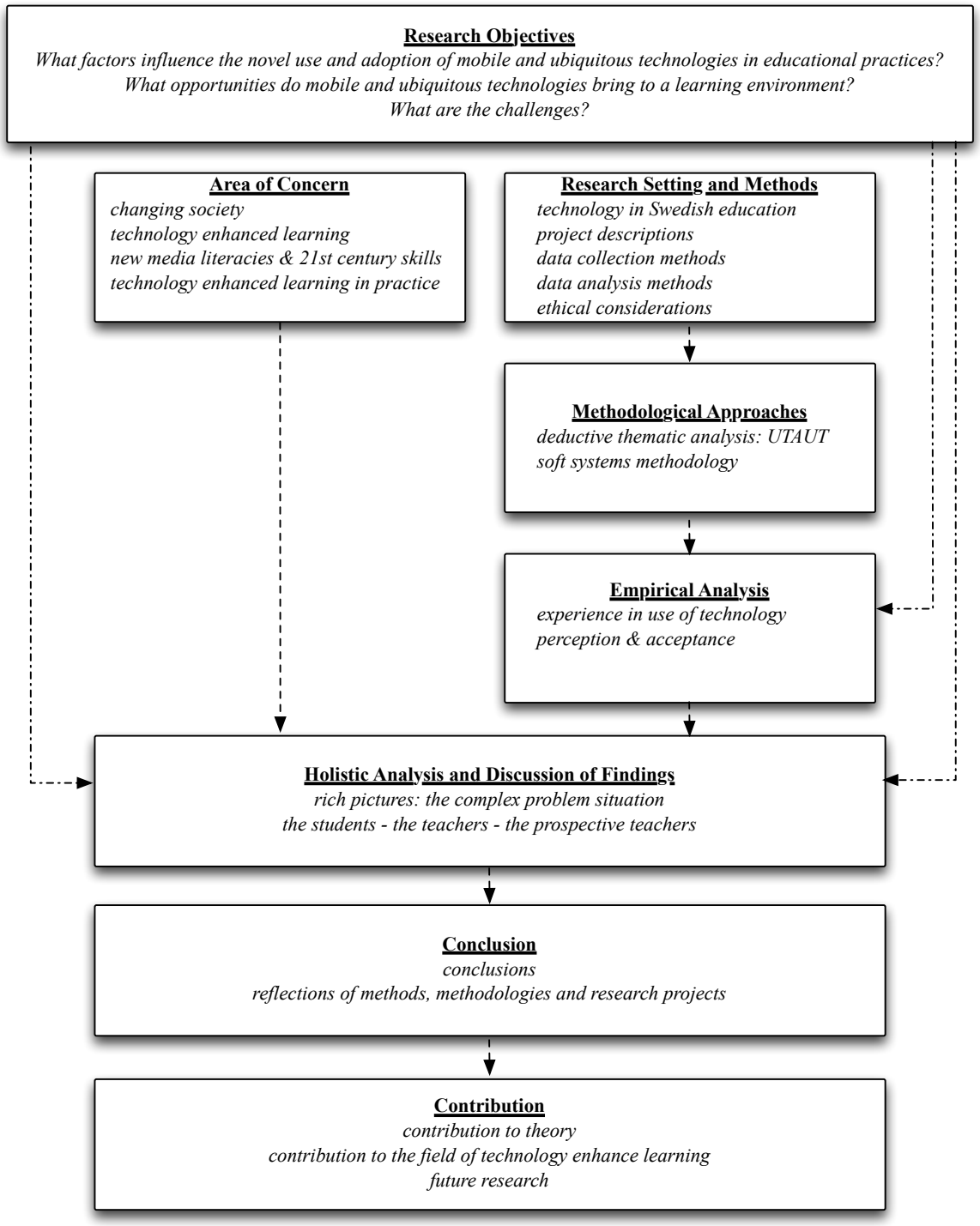


Figure 1.1 Thesis Disposition

CHAPTER 2

Area of Concern

This chapter includes the significance and the role of mobile and ubiquitous technologies in our society. The section describes how technology influences our lives, as well as constituting a major part of it. The following section: the phenomenon of Technology Enhanced Learning, the core of this research, will be introduced. The chapter ends with two ongoing efforts within the field of Technology Enhanced Learning from different places in the world.

2.1 A Changing Society

Information and Communication Technologies, ICT, have become a part of people's everyday life (Bradley, 2006b; Harper et al., 2008; Pachler et al., 2010). Bradley (2006a; 2006b) argues that everyday life is being filled and highly influenced by intelligent technical devices and within the near future these technologies will keep us permanently connected. This can be confirmed by the 2011 Horizon Report, arguing that one of the key trends is that people are expected 'to be able to work, learn and study whenever and wherever they want' (Johnson et al., 2011, p. 3). Mobile devices and access to the Internet has made this possible and frustrations arise when constant access is not available (Johnson et al., 2011). Technologies are becoming ubiquitous, used in almost any activity and are increasingly embedded in more devices and objects (Bradley, 2010).

With the constant development and change in technology, the public, private and professional lives of us humans are affected: the relation between them and also our roles as citizens. The workforce structure, organizational design and structure, work content/task as well as communication patterns and management has changed (Bradley, 2006a; 2006b). Much more and more frequently are we surrounded by computer technologies, communication technologies and media technologies (Bradley, 2006b) and often this is due to the push of technology rather than to the need and requirements of humans (Bradley, 2006a).

Bradley (2010) argues that there is a general trend that several human roles and environments are converging into one environment within the home environment. The professional-, private-, citizen- and learning roles are converging into one life role within one's life environment. This, the author claims, is due to the dominant convergent role of technology (Bradley, 2010). Hence, ICT has had an impact on humans, their identity, self-perception, social competence, creativity, integrity, trust, dependency and their vulnerability, either strengthening or weakening them (Bradley, 2010, p. 187). These changes bring both positive and negative impacts on individuals and, accordingly, it is of great importance to pay more attention to the individual level within the interaction between ICT, Society, and individual (Bradley, 2010).

Due to the increased importance and influence of mobile and ubiquitous technologies in peoples' lives and merging of home-, work, and public life environments, people are able to work at any place and any time, and everyday life has become different. These changes may also affect teaching and learning practices, although the question remains: do schools and educational environments embrace and use mobile and ubiquitous technologies in novel ways to support traditional teaching and learning?

2.2 Enhanced Learning by Mobile and Ubiquitous Technologies

Learning is one of the most basic requirements for humans to live. It is extensive and it can be identified on many different levels without referring to the same thing. Within the world of business, learning refers to learning about organizations, while within brain research the learning could be about nerve cells learning and, within educational settings, we talk about the learning of individuals (Gärdenfors, 2010). In the Oxford English Dictionary, learning is defined as "the acquisition of knowledge or skills through study, experience or being taught"[10]. Learning is made compound by several abilities connected to different memory processes. Gärdenfors (2010, p. 25-26) mentions three dimensions: the first is the *physical* dimension where we learn how to walk, how to ride a bike and how to tie the laces of our shoes. Learning about *concepts* is needed so that humans can handle and solve everyday challenges, such as being able to differentiate between similar fruits, recognize traffic signs and know whether we are walking into a shoe shop or clothing boutique. The final dimension Gärdenfors mentions is *cultural* learning, which, he argues, is to some extent decided by the educational system: learning about letters, counting, the days of the weeks, the history of humans, and geography.

With the evolution of technology the opportunities to learn and teach have taken a turn and changed into ways not previously imaginable (Dillenbourg et al., 2009), enabling possibilities for creating richer, deeper and wider learning (Scardamalia et al., 2010). Mobile and ubiquitous technologies are enabling a new phase in the evolution of the educational field through the opportunity for learning experience across various learning settings (Milrad et al., 2013). Technologies, such as the Internet, have changed our ability to access and process information. The knowledge process has become more effective and cheaper, enabling collaboration not only locally and regionally but also within national and international contexts (Tredwell, 2011). The focus of teaching has now changed from having the outcome of knowing and remembering to understanding and wisdom (Wan et al., 2011). In an economy driven by innovation and knowledge, a world filled with risks and

[10] "learning". (Oxford Dictionaries 2010 http://oxforddictionaries.com/definition/english/learning accessed November 22, 2012)

opportunities, and in a society consisting of complex challenges of business, politics, science, health and environment, education systems have to handle the challenges in order to produce individuals that can be successful (Key & Greenhill, 2011). It is crucial for the younger generation to be literate; to have the ability within a digital information society to learn, collaborate and solve problems (Scardamalia et al., 2010; Griffin et al., 2012b). The challenge education is facing is to provide the young generation with the necessary skills and literacies. The educational system has to move from production-based skills and put the emphasis on information and technological skills (Griffin et al., 2012b).

Due to the changes in economies, the way people live, think and work has altered and so have the tools that are used for living and working. Griffin et al. (2012b) argue that the tools we used 50 years ago are unrecognizable compared to the tools we use today. With the changes in our lives, our thinking and working, there is a requirement for the educational systems to teach new skills focusing, on digital literacy and numeracy as well as new ways of thinking (Lankshear & Knobel, 2011; Griffin et al., 2012b). Despite these changes in society, economies and, foremost, technology, and its effects on the nature of learning and teaching, Laurillard (2009, p. 7) argues that one thing is known and does not change – and that is what it takes to learn, especially within a formal context. Many scholars have, in different ways, been researching this issue and the common argument is that learning is active. This has been argued by John Dewey and further by Piaget, Vygotsky, Freire, Bruner, Papert, Marton and Lave (Laurillard, 2008, p. 527). Children are known to be active, creative and enjoy exploring (Kay, 1972). Kay (1972) refers to Papert, arguing that, when something is considered enjoyable and includes involvement, humans are willing to put many hours of physical and mental effort to reach perfection. He continues that this is to a large extent lacking in school education, where learning is not made interesting for students and there is no immediate enjoyment in learning and practicing general intellectual skills. Students are

> *[…] forced to participate in activities which will not bear fruit for many years and will leave him alienated (mathematics: 'multiplication is GOOD for you – see you can solve problems in books;' music: 'practice your violin, in three years we might tell you about music;' etc.). (Kay, 1972, p. 4).*

Learning is not something that happens to somebody, it is an activity that the learners perform and therefore the teacher's roles is not to transmit knowledge to a passive audience but to engage the learner and practice high-level cognitive skills enabling students to transform the knowledge into their own (Laurillard, 2008). To make students learn, it is important that the teachers provide them with something real and enjoyable to do (Kay, 1972).

Laurillard (2008) claims that it is most unlikely that there will be new, radical findings on what it takes to learn, and learning will always require effortful thinking. The role technology can have in learning is not about what it will take to learn but, rather, it could change the process of how learning is facilitated. Learning with the use of mobile and ubiquitous technologies and digital resources is different from learning without them (Laurillard, 2008; Kay, 1972). Further, it is critically important that education should not be led by and based on technology and technology development but for it to have its own future, taking advantage of the possibilities and opportunities technology enables (Laurillard, 2008). Lankshear and Knobel (2007) argue that it is important to bear in mind that the need for these new technological tools and new literacies and skills is not more important than the standard, traditional literacy. What differs in the New Literacy is that it is defined as literacy

meditated by digital encoding, participation, collaboration, sharing, and so forth[11]. Without the so-called "old literacy" there would be no books, no authorship or research. The new literacies need to be built upon the traditional literacy together with social-, technical-, critical- and research skills in order for the students to be successful in the twenty-firstcentury economy (Lankshear & Knobel, 2007).

Another main challenge facing educational institutions and schools is how to deal with students' informal learning: how to take advantage of knowledge and experiences gained outside the schools; how to bring this knowledge to the classroom; how to connect to the everyday life of the students and their use of mobile and ubiquitous technologies (Jenkins, 2009; Pachler et al., 2010). Many authors agree on breaking the classroom walls and getting out to the real world of the learner, bringing in informal learning to the classrooms and moving outside the classroom and into the learners' environment where the learning becomes more situated, personal, collaborative and life-long (Naismith et al., 2004; Pachler et al., 2010).

The research on mobile and ubiquitous technologies for learning has several focuses and includes various disciplines. It can be said that the field of Technology Enhanced Learning consists of humans (i.e. the learner), technology in terms of different tools, resources, the setting where the learning takes place and the interactions between them (Kurti, 2009). According to Kurti (2009), as illustrated in Figure 2.1, there are three domain challenges to address: (1) technology and engineering challenges, (2), design and interaction challenges, and (3) learning, social and cognitive challenges.

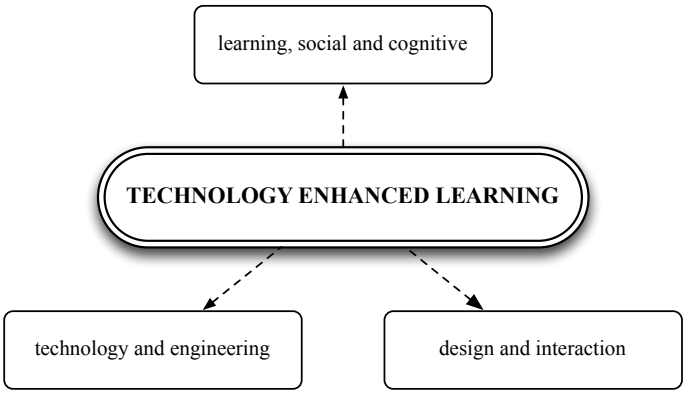


Figure 2.1 Domain challenges of Technology Enhanced Learning (adopted from Kurti, 2009)

Within his studies Kurti (2009) mainly focuses on the technology and engineering domain and touches upon the design and interaction domain. The outcome of the study nonetheless, he states, also closely relate to the learning, social and cognitive domain. This study, however, will not focus on any specific challenge domain but touches upon all three domains and focuses mainly on the relations between the challenges and other potential challenges. Kurti's (2009) model will be used as a reference point in this study.

2.2.1 Integrated Learning Processes

By introducing new technology into classrooms, the relationship to one another of the learner and the teacher and their relationship with traditional communication tools such as

[11] New Literacy will be further defined and explained in Chapter 2.3

pens, pencils, chalks, blackboards, etc. is changed (Jenkins, 2009). The teacher was always supposed to be the one who possesses all the knowledge and, as soon as they complete their teacher training, they are supposed to known how to teach (Sharples et al., 2007). Dewey had already argued in 1929 that the standard judgments of the worth of teachers is based on the immediately successful results of the students, measured for instance by the order in their classroom, the level of correct recitations, exams passed and students moving to higher grades. He further argued that prospective teachers attend teacher-training education with this mindset and want to learn how to do things in order to reach maximum success (Dewey, 1929).

With the wide use of mobile and ubiquitous technologies outside the school setting, teachers are challenged to rethink their role in the classroom: they are forced to act more as facilitators rather than merely a source of information and knowledge. With information available at anytime and anywhere, teachers need to act not only to as guides to how to access information and knowledge but also as filters for creating a foundation for students to understand and distinguish correct information from wrong (Sharples et al., 2007).

As mentioned earlier, according to Laurillard (2009) what can be certain when it comes to the nature of learning and teaching is what it takes to learn regardless of technological change. Through the ages, various elements of the learning process have been the focus of different pedagogical principles and these have, according to Laurillard (2009, p. 7-8), been characterized in four different ways. Table 2.1 presents the four learning elements: (1) Instructionism, (2) Constructionism, (3) Socio-cultural learning, and (4) Collaborative learning. The table also gives a short description of each learning element and their original founders.[12]

Table 2.1 Elements of the Learning Process

Learning elements	**Description**	**Theoretical founder**
Instructionism	Influences the use of presentation and testing the capabilities of technology. Instruction is the main focus and learning is tested by use technology: e.g. multiple-choice questions, right/wrong feedback	Instructional theories by Gagne, 1970, 1997 Merill, 1994
Constructionism	Emphasizes importance of construction as a learning aspect. Constructing models or objects with technologies enabling programing, stimulation and modeling	Derived from Piaget Coined by Papert, 1991
Socio-cultural learning	Importance of discussion to achieve learning, and the use of communication technologies	Vygotsky, 1962
Collaborative learning	Combining social and constructive elements of the learning process and using technologies that support both	Piaget and Vygostsky Dillenbourg et al. 1996 Scardamalia and Bereiter, 1994, 2006

[12] The full references can be found at the end of the bibliography chapter

The different elements of the learning process are equally important and each generates different conventional teaching methods and, hence, different uses of technologies. In traditional education the learning ends with a summary by the teacher, based on the teacher's ideas. Laurillard's (2002; 2009) Conversational Framework, see Figure 2.2, demonstrates the relation between the learner and the teacher as well as the relation between levels of theory and practice. The conversational framework acknowledges the learning elements (see Figure 2.2) as well as the actors within a teaching and learning context: the teacher, the learner and the learner's peers. In digitally-facilitated education the student's ownership of their thoughts and ideas is preserved through the whole learning process and their contributions in different forms is presented in the classroom, answering the teachers overall question.

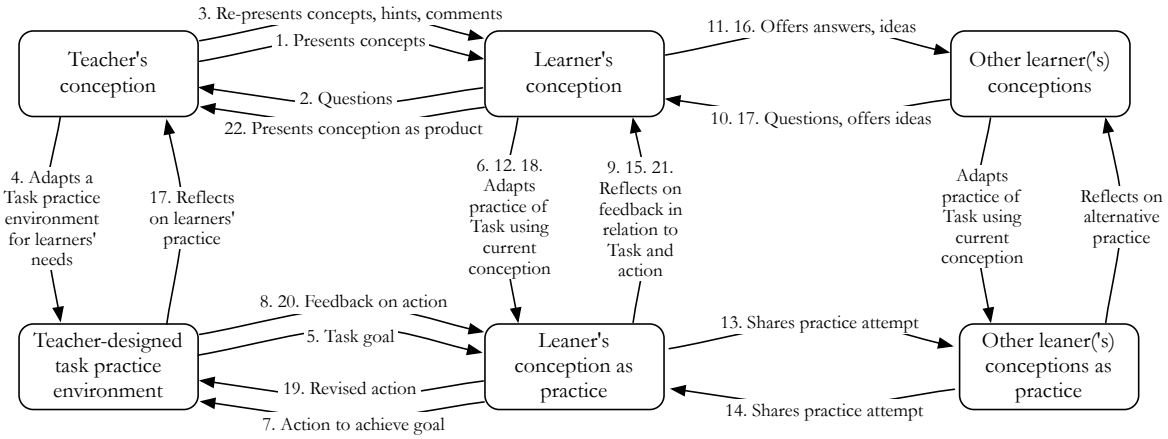


Figure 2.2 The Conversational Framework (adopted from Laurillard, 2002; 2009)

The complexity of the interaction between learners and teachers and between the levels of learning theories and practice is presented in the framework integrating the four elements of learning; (1) Instructionism, (2), Constructionism, (3), Socio-cultural learning, and (4) Collaborative Learning. The number presented in framework (see Figure 2.2) illustrates the order of the activities and the numbers should be considered as a whole for the complete framework, and not for each element. In the figure, several lines have more than one number and this shows the interaction existing within the framework.

The instructionism element can be identified in the left and middle of the conversational framework (see Figure 2.2) and separately illustrated in the top left corner of Figure 2.3. In the instructionism element, the teachers present a task, a goal the student is supposed to achieve and, after submission, receive feedback, comments, hints, additional material and/or new tasks (see Figure 2.3a). The lower left corner of Figure 2.3 which corresponds to the lower left side and middle of the whole conversational framework (see Figure 2.2) covers the constructionism element (see Figure 2.3b), describing the process for students in developing their understanding by repetition to achieve a certain goal. Their conception is fine-tuned by enabling the relationship between concept, goal, action and feedback. The student's understanding will be different when *performing* some action in contrast to only reading about it.

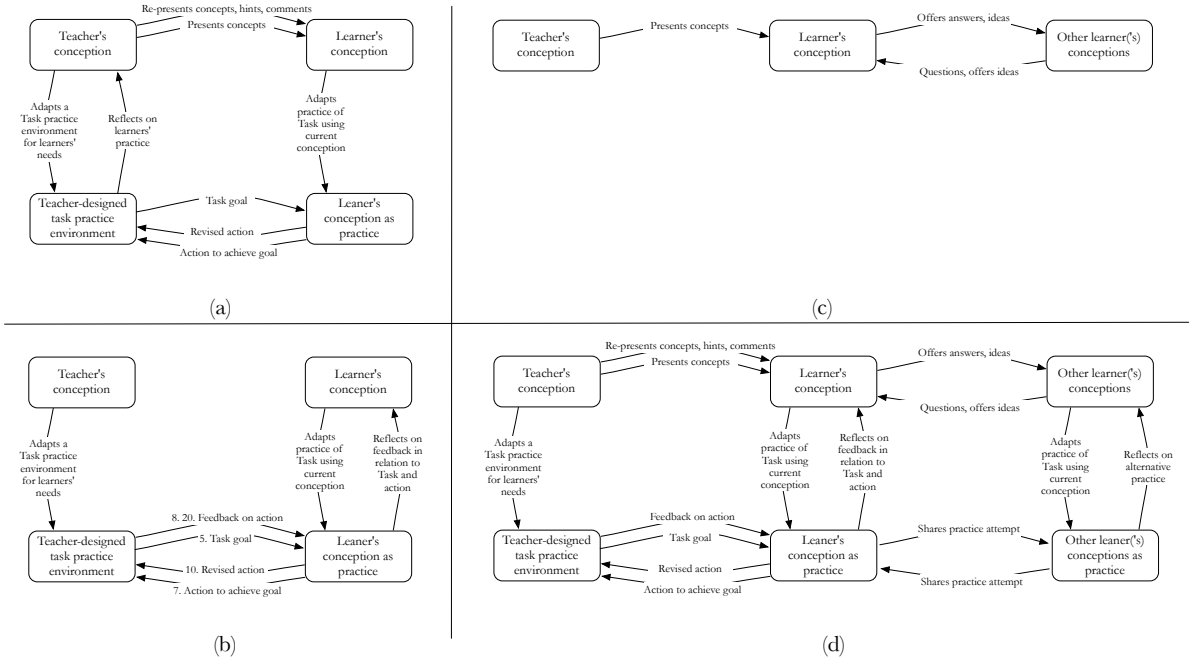


Figure 2.3 The learning elements of the conversational framework (adopted from Laurillard, 2009)

To discuss with peers, having to articulate and argue about ideas but also to ask questions, enables a continual iteration of discussion which is the main argument of the sociocultural element, represented in the top right corner of Figure 2.3 and the top right side of the conversational framework (see Figure 2.2). The teacher's role in this element is minimal and consists mainly in providing the task. The final element, collaborative learning, illustrated in Figure 2.3d merges, as stated in Table 2.1, the sociocultural- and instructionism elements, covering most of the framework but also introducing the practical aspect of other learners, illustrated in the lower right corner (Laurillard, 2009).

Laurillard (2009) argues that traditional methods, i.e. as conducted over the last few decades, must be explored in their new context, which also means embedding studies of learning through technology within an understanding of the existing classroom. However, "traditional education" can only be properly explored in relation to the "new" technology and knowledge-driven world from a perspective that is capable of challenging both (Laurillard, 2009).

The 'new world', as it is called by Laurillard (2009) and as mentioned above, needs to include new knowledge that the students need in order to be successful. This knowledge will be presented in the following section.

2.3 New Literacies & 21st Century Skills

By entering the 21st century and leaving the 20th century behind, there is a clear difference in not only the global economy but also the societies' social trends: on how people access, use and create information and knowledge. This is mainly due to the information and communication technologies available today where technology-based information has changed the role of information and thereby the structure of the workforce (Bradley, 2010; Scardamalia et al., 2010; Griffin et al., 2012b). For the younger generation to become active and successful in society there is a need for new sets of skills and literacies (Jenkins, 2009; Scardamalia et al., 2010, Lankshear & Knobel, 2011; Griffin et al., 2012a).

New Literacies

Lankshear and Knobel (2006, p.64) define the concept of literacies as "social recognized ways of generating, communicating and negotiating meaningful content thorough the medium of encoded texts of participation in discourses". Literacy is not about how to read and write particular texts or symbols but to apply that knowledge and skill for specific purposes in specific contexts (Lankshear & Knobel, 2006).

Concerning "new literacies," Lankshear and Knobel (2006; 2011) argue the concept of "new" to be referred to as new kind of "stuff". They distinguish between new technical stuff and new ethos stuff, where the former concerns the "digitalism," that is the ongoing development growth of digital and electronic technology and the use of programming languages for writing programs, storing and retrieving data. With the ethos stuff they refer to the emergence of modern mindsets (Lankshear & Knobel, 2006). Lankshear and Knobel (2007) further continue that the more a literacy practice involves and uses technical stuff the more likely it can be regarded as new literacy. However, Facebooking, searching and downloading music or video clips or following online lectures on YouTube or on a similar service and not participating or contributing is not considered new literacy. Literacy can be defined as new literacy the more it is mediated by digital encoding, participation instead of publishing, collective intelligence instead of individual intelligence, collaboration instead of individual authorship, sharing instead of owning, innovation instead of evolution, relationship instead of broadcasting, etc. (Lankshear & Knobel, 2007, p.228). The "new" should be considered as a new way of thinking about literacy as a phenomenon and not new literacies as such (Lankshear & Knobel, 2011).

21st Century Skills

Scardamalia et al. (2010) refers to 21st century skills as coming from business people with the aim to equip the youngsters with skills in selecting and using technology when dealing with communication, collaboration, problem solving but also everyday living. Griffin et al. (2012b) argue that 21st century skills are those skills required and essential for living and being successful in the 21st century. The working environments of the 21st century is rich with technologies, ill-defined and based on multidisciplinary teams requiring skills such as problem solving, creativity and innovation (Griffin et al., 2012a; Wan et al., 2011). There is a need for knowledge about the rest of the world, to develop people's skills in a different way, use new and different sources of technology as well as "thinking outside the box" (Wan et al. 2011). The schools, afterschool programs, and also parents in the home environments, should be involved in encouraging and supporting these skills (Jenkins, 2009).

The young of today are living in an era where they are actively involved in a participating culture: a culture in which the members believe in contributing, sharing and being socially connected with one another. There is strong support for creating and sharing these creations and also for an informal mentorship where knowledge is passed along, while at the same time there is a rather low barrier on artistic expression and civic engagement (Jenkins, 2009). Being part of this participatory culture, the youngsters develops new skills needed in the modern workspace and a more powerful understanding of citizenship. These skills can be achieved during everyday life, although researchers believe that education needs to provide these skills, as it will determine the level of success of each youngster (Jenkins, 2009).

The 21st Century skills consist of, among other things, collaboration, transmedia navigation, creativity and innovation, literacy, new ways of thinking, etc. (Jenkins, 2009;

Binkley et al., 2012). These skills are needed for new ways of working, living, learning but also thinking: to be able to manipulate the information-based tools; analyzing the credibility and utility of information; to evaluate the appropriateness of information; and how it best can be used (Griffin et al., 2012a). The skills and cultural competencies include social skills though collaboration and networking and should be built upon the foundation of traditional literacy and skills such as research, and technical and critical analysis skills taught in schools (Jenkins, 2009). Binkley et al. (2012) argue that the concepts used within 21st century skills have been close to skills that have been taught in schools for many years. The authors claim that the question to be asked is to what extent mobile and ubiquitous technologies can change and/or enhance these skills that have been taught in schools.

2.4 Technology Enhanced Learning in Practice

In addition to the projects presented for the empirical work of this study, this section will present two projects within the research area of Technology Enhanced Learning. These projects illustrate how different mobile and ubiquitous technologies in a European and an East Asian country have been used in novel ways in order to enhance the learning and understanding of the learners.

The novelty in the first project is how mainly computers are used to enhance first-grade children's reading and learning skills on an everyday basis without focusing on esthetics and giving all students the same conditions and prerequisites. The second project is a seamless project using different mobile and ubiquitous technologies in novel ways that enable formal and informal learning as well as collaboration and individual learning at any time and place where there is interest and motivation for learning.

2.4.1 Learning to Write Without a Pen

In Kungsgården compulsory school located in central Sweden, all students in the first grade are taught how to read and write with the use of computers, sounding keyboards and speech synthesizers.

The teacher in the class explains and shows the students how to work with their files they create, save and retrieve in Microsoft Word. The students work in groups of two, where each one of them has their own text that they work with but can at the same time help and learn from one another.

The students start by opening the speech synthesizer software, choosing one of the voices. There after they can open their word files and mark the text they have previously written and get it read by the voice and at the same time follow the text. By using a sounding keyboard and the speech synthesizer, all children will learn to read and write regardless of prior experience and knowledge. The sounding keyboard sounds each letter the students put their finger on, helping the students to not only learn letters but also help them to make the sound. The teachers in the class believe the most important issues when learning to read and write is to make the connection between the letters and the sounds. This is something that always has been the focus with pen and paper but the difference when using computers is that it comes automatically. The repetition that is essential for learning becomes more pleasurable.

These sorts of technologies are mainly used within special pedagogy but have now, through the effort of the teachers within the school, been offered and used by all students.

The teachers argue that in this case all students can learn and succeed based on their own qualifications and pre-knowledge. By using computers at an early stage like this, difficulties in reading and writing can be eliminated in later years as the learning focuses on the connection between letters and sounds and not how one is writing and the perfection of the handcraft. The motor activity of many children in those ages is not fully developed and their small hands are not completely prepared for writing. Yet in schools students write pages and pages of letters and for some children this becomes a frustration and thereby a discouragement. By not using the pencil until second grade the students do not need to learn how to handle the pen and focus on how to write each letter but rather to better learn the letters of the alphabet, to read and to write. Further, the students are able to focus on what they are writing as they will be able to keep their thread of thought while writing on the sounding keyboard with the sound synthesizer instead of getting the shape of each letter correct and enough space between the words. Many children coming to school are filled with excitement and the first thing they are asked to do is to write letters – first on paper and then in notebooks. This process will take up to a whole year and can in many cases become tiring for the children.

Working with these sorts of technologies further enables a dialog between the students and the teachers, as the teacher acts as a facilitator who, together with the students, spells out the sounds of letters and words but also creates a space to discuss sentence structures and difficult words. In traditional reading and writing classes the teachers' role is mainly to correct assignments and little open dialog exists between the teachers and students.

By the end of the first year in school, each student is provided with their own email address connected to the school and they are given a full week of teaching on the use of emails. Thereafter the teachers send emails to the students and each one of them has to reply. The emails can for instance consist of one of the teachers writing that she has been on vacation to a country, attaching the flag of England and a double-decker bus, asking them where she has been and what the capital of that country is. After receiving replies from each of the students she continues asking new questions such as "Have you been abroad" and so forth.

The leader of the project who teaches this class argues that the teachers need to embrace the technology and not let their own thoughts get in the way. The teachers have to decide that, now, we will put the pencil aside: the computers will give enough writing training (Vestlin, 2009).

2.4.2 Learning by Logging

In an ongoing research project in Japan, researchers are focusing on capturing learning experiences in everyday life to share and reuse for learning. By using a Ubiquitous Learning Log, known as ULL, learners can log their learning experiences through photography, audio, video, location, sensor data, using ubiquitous technologies and then share their logs with others. After creating a ULL, the learner can use a custom-developed log system called System for Capturing and Reminding of Learning, SCROLL, for asking questions and receiving answers, or taking quizzes based on their own and others ULLs. This system can be used individually or collaboratively in both formal and informal settings and, by combining several devices such as desktop computers, laptops, smart mobile phones and across different subject disciplines, seamless learning is enabled. The system is currently being used in an initial pilot for learning English vocabulary at University level combining in-class and out-of-class settings.

The generic process consists of four stages: (1) log, (2) organize, (3) recall and (4) evaluate. The process is initiated with the learner logging what they have learned, and it is recorded in the system. The system compares the new logs with previous ones in order to match similar ones to then create a structured and organized knowledge base. In the third stage the learner can practice and rehearse previous logs. This can be done through quizzes and reminders created by the system. The final stage consists of evaluating and analyzing the past by looking into what the learner has learned and how. This way, the learner can improve their learning and the system can refine and adapt the organization of the logs based on the learners' evaluation. This is an iterative process where all new logs get stored and new logs can be added and combined with previous ones to enhance the learning (Milrad et al., 2013).

2.5 Summary

This chapter has given an overview of the changes in society and, hence, the lives that we now live, and how this affects the educational system. It also included what is needed for the younger generation to take with them into the future, and how this can be provided by the teachers and the school. The importance of technology in the everyday world and the challenges and opportunities brought to educational practices have been presented in order to create a background for the understating of the aspects influencing novel use of mobile and ubiquitous technologies in everyday teaching and learning

Next the empirical foundation of this study will be presented, along with the use of mobile and ubiquitous technologies in Swedish compulsory schools. It will also present the data collection methods and the analysis.

CHAPTER 3

Research Setting and Methods

This chapter will initially present the current state of mobile and ubiquitous technologies in Swedish compulsory school. Second, the research setting and the projects the empirical foundation this study is based upon will be presented. Then the research methods will be presented and described and, in the final section, the ethical considerations will be addressed.

3.1 Use of Ubiquitous Technologies in Swedish Compulsory Education

As of autumn 2011, all schools in Sweden have applied the latest curriculum, Lgr11, for the compulsory school system, the preschool class and the leisure-time centre. The curriculum is provided by the Swedish National Agency for Education[13]. Lgr11 accounts in detail for the "fundamental values and tasks of the school", the "overall goals and guidelines for education" and "syllabuses which are supplemented by knowledge requirements" (Skolverket, 2011, introduction). In the "Overall goal and guidelines," the section of "Knowledge" Lgr11 is written the following in concern to technology:

> *The school is responsible for ensuring that each pupil on completing compulsory school: […] can use modern technology as a tool in the search for knowledge, communication, creativity and learning.* (Skolverket, 2011, pp.13-14)

According to the newest Swedish School Act, 2010:800, every child should have at no cost access to books and other learning tools for an up-to-date education (SFS, 2010:800, Chapter 10; §10). The Swedish IT policy; "ICT for Everyone – A Digital Agenda for Sweden" argues that the Swedish School Act and curriculum follows the "Digital Agenda for

[13] Skolverket in Swedish

Europe" from the European Commission (Näringsdepartementet[14], 2011). It is written in the Swedish IT policy that "Schoolchildren must, and teachers should, have access to modern learning tools that are required for cotemporary education" (Näringsdepartementet, 2011, p. 33) and, further, that the responsibility for issues concerning technology in schools rests upon the municipalities and the school managements. The policy argue for the importance of teachers understanding the importance of, and having the expertise in use of these new opportunities in relation to the students, to conduct their everyday work, and also for communication with parents. The IT policy explicitly mentions the lack of explicit instructions on how the knowledge is to be conveyed: it is for the teachers and the school management to decide how these instructions are to be conducted and achieved (Näringsdepartementet, 2011 p. 34).

A report from 2010, published by the Swedish National Agency for Education, states that the use of computers in many school subjects is very limited. Computers are mainly used for writing and for searching the Internet (Thullberg & Millstam, 2010). The Swedish School Inspectorate[15] reports the computers to be used mainly to type texts that have been written by hand beforehand or to search for information (Skolinspektionen, 2012). Primary schools rarely, or never, use computers, while of the high school students, who are the most frequent users of computers in their education, only three out of ten regularly use computers and then mainly in social studies and Swedish language classes. Computers are rarely used for mathematical education or subjects within the natural sciences (Thullberg & Millstam, 2010; Skolverket, 2013). Since 2008, when the latest report from the Swedish National Agency for Education on measurements on teachers and students requirements on IT use and existence of IT competencies came out, access to computers has increased. Both teachers and students have better access and there is also an increasing trend in the number of laptops (65 per cent of all student computers) and tablet-devices (10 per cent of all student tablets). However, as mentioned above, the use of computers is limited and more or less the same as it was in 2008 and computers are still mainly used for searching information online and as a typewriter (Skolinspektionen, 2012). In a report from the school year 2011/2012, the Swedish Schools Inspectorate concludes that the investment in technology is not being used for school education. They report that only exceptional schools and mainly individual teachers used technology in an integrated way where both teachers and students use it in an active way that motivates and enhances the students' understanding of the subject. The technology is mainly used for administrative tasks and rarely as a supporting tool for pedagogical work (Skolinspektionen, 2012). Within the time period of 2008-2012, the number of interactive whiteboards in compulsory classrooms has trebled as 33 per cent of all school classrooms are now equipped with interactive whiteboards. However, they are not used optimally as the interactivity is used sporadically and then to show movies and images rather than being used by the students (Skolinspektionen, 2012; Skolverket, 2013).

The teachers' attitude towards IT varies (Skolinspektionen, 2001; Skolinspektionen, 2012): some teachers are more skeptical about the added value and are worried about technical problems and it being time consuming while others are more enthusiastic. About four out of ten teachers believe that IT gives opportunities to adapt the teaching to a greater extent to the students different needs and to increase motivation and to stimulate the learning process, while fewer believe in the use of IT to increase the students' ability in problem-solving (Skolinspektionen, 2011; Skolinspektionen, 2012). The difficulties that arise during use and the lack of technical support, namely IT-pedagogical support, have been

[14] Ministry of Industry, Employment and Communication in Swedish

[15] Skolinspektionen in Swedish

shown to limit the teachers' use of IT in their teaching but also in their other duties as teachers. The desire for training and updating of the competencies of teachers is very high and, during recent years, the training required by teachers has changed from being mainly how to use IT and basic knowledge to how to benefit from it as a pedagogical support. However, approximately one fifth of 1754 teachers (with a total of 2900 teachers included in the follow-up) still believe they do not have good enough knowledge and competence in general IT use (Skolverket, 2013).

A more extensive report by the Swedish School Inspectorate from 2011 reports that the majority of educational institutions have an IT strategy. This should include the standards and maintenance of the IT equipment, training and education for personnel; IT as a pedagogical tool; and improving the students' ability to search for information on the Internet. Despite this, most IT strategies only deal with issues concerning the technological equipment (Skolinspektionen, 2011, p. 4), which reflects both IT policy failing to address the lack of specific instruction about approaches to IT use, as mentioned above, and the National Union of Teachers[16] trying to address the need for a national strategy in order for teachers to be able to use IT to more efficiently increase the students knowledge level (Lärarnas Riksförbund, 2010, p. 7). The lack of national and local IT-strategies has had a generally negative affect on the attitude and willingness to use IT among most teachers, and the actual use of IT depends on the individual teacher's attitude and knowledge (Skolinspektionen, 2011). According to the 2013 report by the National Agency for Education, the existence and availability of IT-policies and IT-plans for compulsory school level has decreased in comparison to the prior follow-up done in 2008, despite the increased investment in IT in the schools. It is further reported that the headmasters and managers of the schools believe they lack the IT competencies required and need to lead and manage the work of the IT strategy of their schools. They do not know how to further develop the use of IT in the teaching or how to manage legal issues (Skolverket, 2013).

For many schools in Sweden, the purchase, administration and management of the technological equipment is done by the municipality and this creates a situation where the needs of the school are not meet and the IT equipment is not always sufficient. This combination of the lack of IT-support and lack of control over management of the technology restricts and limits the development of technology-enhanced pedagogy, even where ambition and competencies exist (Skolinspektionen, 2012).

3.2 Research Setting

The context of the empirical foundation upon which this research is based will be presented in this section. This study draws upon projects conducted at the multidisciplinary Center for Learning and Knowledge Technologies (CeLeKT) research group located at Linnaeus University, Sweden. The main focus of the CeLeKT research group is developing and designing interactive learning environments and applications with innovative use of mobile and ubiquitous technologies in various collaborative learning environments (CeLeKT, 2011).

The three projects that the empirical foundation is based upon are: Geometry Mobile (GeM), Learning Ecology with Technologies from Science for Global Outcomes (LETS GO) and Collaborative Learning Using Digital Pens and Interactive Whiteboards (Collboard). All projects have been conducted at local compulsory schools in Växjö municipality, in collaboration with teachers, students and fellow researchers. The tools and activities for each

[16] Lärarnas Riksförbund in Swedish

project have been designed and developed by researchers at the CeLeKT research group. Table 3.1, gives a summary of selected trials of each of the projects.

Table 3.1 Project Overview (adopted from Salavati & Mörtberg, 2012b)

	Subject	**Grade**	**Technology**	**Number of participants**	**Trial dates**
GeM	- Mathematics	- secondary school	- Mobile phones - Augmented Reality - Laptops	- 11 students - 5 teachers	- May 2009 - Oct. - May 2010/2011
LETS GO	- Ecology and Environmental Science	- secondary school - higher education	- Mobile phones - Sensors - Laptops - (Interactive Whiteboard)	- 75 students - 4 teachers - 16 prospective teachers	- Nov 2009 - April 2010 - May 2010 - May 2011
Collboard	- Mathematics	- secondary school	- Digital Pens - Interactive Whiteboard	- 12 students - 2 teachers	- April 2010

Within each project, several trials could be conducted, each consisting of several days of what are called in LETS GO, inquiry circles or sessions, and sessions as they are called in the Collboard project. Within the GeM project there were three iterations of the project where the focus of each version was different and each iteration of the project consisted of several related trials.

The trials in Table 3.1 have been chosen due to the rich data, enabling rich data analysis focusing on the intended aim of this study. More details on the data are included in Table 3.2.

3.2.1 GEM

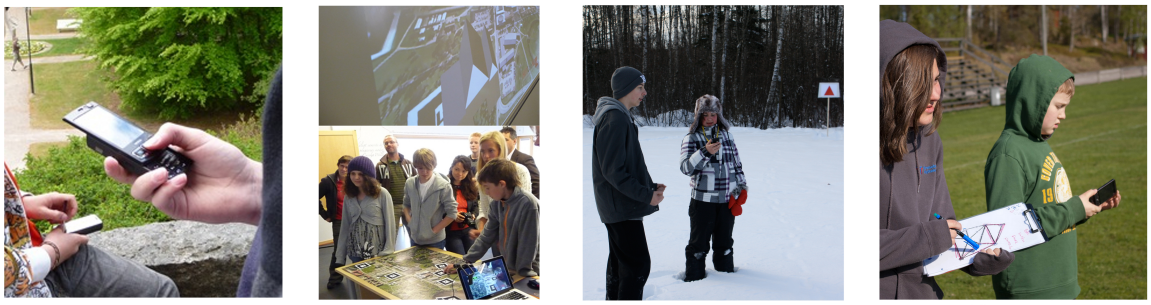
The Geometry Mobile, GeM, project is part of the Advanced Mobile and Ubiquitous Learning Environments for Teachers and Students, AMULETS[17] project. The GeM project was initiated during fall 2008 and has since had several iterations (Spikol 2010[18]; Sollervall et al., 2011; Gil, 2012). The GeM projects' general aim was to develop and design a mobile-learning activity in an outdoor setting to make mathematics, specifically geometry, more tangible for secondary school students. An additional aim was to create an opportunity for the students to collaborate, discuss and solve mathematical problems (Spikol, 2010).

In the first iteration, the outdoor activity consisted of measuring and calculating the height of a castle and the area of a closed field located on the Linnaeus University campus in Växjö using two mobile phones (Spikol, 2010). The students were initially asked to guess the height of the castle and then by using a traditional counting method and, finally, by calculating the height using the distance calculation application on the two mobile phones. Figure 3.1a illustrates two students at the castle with their mobile phones calculating the

[17] More information can be found at CeLeKTs webpage: http://www.celekt.info/projects/show/11

[18] Eliasson et al., 2010; Nilsson et al., 2010; Sollervall et al., 2010

height. The same was done on a football field where they had to calculate the area using the same procedure. The outdoor activity was connected to the second phase of the trial: an indoor activity were the students created a 3D-model and visualized the model with augmented reality. The idea was that the students would create a model of a new building, based on their calculations outdoor, that could be created on Växjö campus. As illustrated in Figure 3.1b, the students are standing at the table with the campus map with the different tags with their 3D-models. The top of Figure 3.1b presents the augmented buildings. The GeM project was conducted with a co-design approach, where three teachers from three different local schools were closely involved in the development and design of the activity.



(a) (b) (c) (d)

Figure 3.1 The GeM Project

The second iteration of the project was a spin-off from the first iteration, calculating and guessing heights of buildings and visualizing the guesses with augmented reality. The trial was conducted with one of the schools participating in the first iteration. This trial is not included in this thesis due to lack of interview-, survey-, and observation data.

The third iteration of the GeM project was conducted during the winter of 2010 and spring 2011. It has so far been the most extensive iteration. This version of GeM was made up of three different-though-related trials with twelve students in fifth grade at a school in Verdeslöv, located 15 km from central Växjö. The aim of these trials was to discover and use geometry as a problem-solving methodology, gaining understanding and more knowledge about spatial orientation by communication, collaboration and coordination (Sollervall et al., 2011a; Sollervall et al., 2011b; Yau et al., 2011; Gil, 2012). Similar to the previous GeM iteration, this version of the GeM trials used mainly mobile technology, this time with greater use of GPS technology and with a more complex application. The focus of the first trial was for the students to coordinate two given distances, based on two fixed points marked as a triangle and a square. The activity was performed outdoors on a field covered with 20 cm of snow, illustrated in Figure 3.1c. The outdoor activity was followed by an indoor activity two days after the first activity where the students were given 10 maps with their individual attempts so solve the task with the aim of making them discuss the different strategies they have chosen for solving the task and reaching the goal (Sollervall et al., 2011a). The second trial was conducted in February 2011. The task was more complex than the previous task and involved multiple coordinations of distances. Prior to the task conducted outdoors, the students were asked in class to decide upon a strategy for reaching the final goal point. To do this they were given maps of the construction with marked distances on each edge from the two starting points, the same fixed points marked as a triangle and square just as in the previous trial, and with a circle as the goal. The students on the second day of the trial were sent outdoors to the same field to perform the task based on the strategy decided upon. The groups of students were the same as in the previous trial although for this trial the students

the students (Sollervall et al., 2011a; Sollervall et al., 2011b). The last trial in this iteration of GeM was taken a step further and was based on the previous task where the students had reached a goal point; this time they also needed collaboration between the groups. By using the strategies they had discussed before the outdoor activity based on the second trial, they were to reach a point where all three groups had to collaborate in order to find the final target. In Figure 3.1d, two of the students from one of the groups are shown with one of them are holding the strategy map and the other student is holding one of the phones.

The outcome of the trials resulted in several mobile applications, an authoring tool, and a design tool kit (Spikol, 2010; Gil, 2012).

3.2.2 LETS GO

CeLeKT researchers together with Stanford University, US, conducted the LETS GO project initiated in 2008[19]. LETS GO was a four-year project, ending late 2012, with the aim of designing and developing activities for collaborative learning, within the field of ecology and environmental science, using mobile and sensor technologies and wireless internet as support, enabling students to capture data and analyze and to reflect on the results (Spikol, 2010; Vogel et al., 2010; Pea et al., 2012).

LETS GO has evolved in a number of trials with, mainly, two local schools in the Växjö area but, since the project is conducted in collaboration with Stanford University, a number of trials have also been conducted in the United States. As a result of the success and great appreciation of the project, there are ongoing efforts to expand the trials to other cities in Sweden and also collaboration with other countries outside Europe and the US.

The general process of a LETS GO trial is based on 3 to 4 inquiry circles. The project is initiated by an indoor session where the students are given an introduction to an environmental problem we face in the world today. The water-quality task presented to the students ends up asking them if they would be willing to drink the water they are going to examine and whether the fish Nemo (from the animated movie *Finding Nemo*) would be able to survive in that water. The first inquiry circle consisted of a session where the technology was introduced to the students and they were given instructions on how to use the mobile phone and the sensors. They were asked to measure a number of water samples, as illustrated in Figure 3.2a, provided by the teacher, and match it to the different locations from where the teacher had collected the water (e.g. local lake, sea side, dishwasher water, heated water, etc.).

(a) (b) (c)

Figure 3.2 The LETS GO Project

[19] The project was mainly financed by Wallenberg Global Learning Network with support from National Geographic, Intel Research, and Pasco

In the second inquiry cycle, the students perform the same task, this time with more space to use the technology themselves. The session ended with a discussion where the results of the different groups were discussed and also about which water would suit Nemo best. The next session, inquiry cycle three, was the main project cycle: the students were sent outdoors to a local lake to measure the water quality at a number of pre-decided places around the lake. Figure 3.2b illustrates how the students measure the water quality at the lake with the sensors and report the data to the application on the mobile phone as well as taking notes on paper. The students were asked to take three samples from each place at the lake. The fourth and final inquiry cycle was a follow-up to the previous cycles and concluded in the classroom with the students discussing the results of their data collection with help of computers, where the result of each group is visualized online, as illustrated in Figure 3.2c. The discussions were at first carried out within each of the students groups but at the end of the session the teachers brought the discussion to a class level, where the students can see their own and other groups' results and can make comparisons and discuss their findings.

The generic process of each LETS GO was conducted for all trials, with minor changes and different lakes based on the location of the schools participating in the specific trial. The outcome of the trials resulted in a mobile application for collection of data in the field and a visualization tool (Vogel, 2012).

3.2.3 Collboard

The third project is the Collboard project. Collboard was conducted at a 7th grade class during spring 2010. The aim of Collboard was to support New Media Literacies, collaborative problem solving and knowledge-sharing, by stimulating collective intelligence, distributed cognition, transmedia navigation and visualization skills. Collboard enables seamless interactions across different media using digital pens and interactive whiteboards to support individual work as well as creating a space for collaborative knowledge construction and encouraging active student engagement and participation (Alvarez, et al., 2010; Alvarez et al., 2013).

The project consisted of four sessions, each lasting between 40 and 60 minutes, in the field of mathematics, namely fraction and algebra. In total the project involved two teachers and 12 students divided in two groups of six.

Each session started with the phase of a mathematical task given by the teacher and the students were asked to solve this task individually by using digital pens, as illustrated in Figure 3.3a. After the submission of the task, the teacher chose three solutions for further discussion at the Interactive Whiteboard (IWB). The solutions are based on the solving approach, disregarding whether or not the final answer was correct (Alvarez et al., 2013; Salavati & Mörtberg, 2012a; 2012b)

(a) (b)

Figure 3.3 The Collboard Project

During the second phase of each session the students who submitted one of the chosen solutions presented their approach to solving the task at the IWB. The next step was for the students to discuss and collaborate to reach a final, 'ultimate' solution together. The discussion was conducted in collaboration with the rest of the students in the class where they together decided how to reach the final solution by choosing fragments of the different solutions presented on the IWB. Figure 3.3b illustrates one of the students selecting part of his solution on the IWB inorder to move it to the collaborative construction area. The teachers' role in the project was mainly to support and help the discussion. Hence they were mediating rather than leading the discussion and making it possible for the students to collaborate on their own (Alvarez et al., 2013; Salavati & Mörtberg, 2012a, 2012b).

The outcome of the project was, beside using the Collboard software, enhanced learning among the students, as they believed their understanding had increased. The students explained they had better understanding of fractions and algebra after the trial (Alvarez et al., 2013)

3.3 Data Collection Methods

The collected data, for the projects presented in Table 3.1, consists of surveys, interviews and observations as well as data logs, screen-, audio- and video recordings, photos, tests, solutions and notes from each of the students. The empirical material used in this study builds on interviews, surveys and observations[20] because of its richness compared to the other collected data. In Table 3.2 a detailed summary of the data collected used in this study is presented.

3.3.1 Interviews

All interviews in each project have been semi-structured (Creswell, 2009), enabling follow-up questions and giving space for the informants to elaborate on issues they found were important or something the researcher found interesting, or based on the lead researchers' instruction and research aim. The interviews lasted between 30 and 60 minutes, following an interview guide and were conducted after specific sessions in some trials. The interview guide was developed in collaboration with fellow researchers, either in Swedish or in English depending on the language skills of the researchers involved as well as the informants.

[20] The interview and observation guides as well as the surveys have been attached in the appendix

While the interviews were usually conducted by two Swedish-speaking researchers, some rare interviews were performed by non-Swedish speaking researchers. The interviews were always recorded with a Dictaphone.

The interviews were transcribed with the use of the software ExpressScribe. The transcription was done verbatim. For each transcription, corrections were made by listening to the interview once more. When the whole interview was transcribed, spelling errors were corrected. In the cases where the interviews were conducted in Swedish, the transcriptions were translated into English.

Not all participants in the trials were interviewed. The table below gives an overview of the interviews conducted as well as the other collected data that have been used in this study.

Table 3.2 Data Collection Overview (adopted from Salavati & Mörtberg, 2012)

	Interview	**Survey**	**Observation**
GeM	18 interviews with teachers (3 teachers, 6 interviews each) 2 interviews with students (2 students, 1 interview each) 1 interview with one student group (3 students)	One survey with 6 students	One full day session
LETS GO	5 interviews with teachers (5 teachers, 1 interview each) 3 interviews with students (3 students, 1 interview each) 4 interviews with prospective teacher groups (2 groups, 2 interviews each)	Two surveys with 16 prospective teachers	3 full day sessions each consisting 15 groups with 2-4 students in each group
Collboard	2 interviews with teachers (2 teachers, 1 interview each)	One survey with 12 students	2 x 40-60 minute sessions with 3 group observations 1 observation with both groups

Table 3.2 presents the number of interviews, surveys and observations within the different projects. The interviews could either be conducted individually or in groups depending on the aim of the trial/project and the lead researcher.

3.3.2 Surveys

The surveys were mainly developed in English in collaboration with fellow researchers. Most surveys were Likert-based 5-scale questions with a few open-ended questions. They were usually given to the students to fill in after participating in the trial. However, in the LETS GO trial with the prospective teachers, the participants were given a pre- and a post

survey. As the surveys were usually aimed at the students, the surveys were translated into Swedish.

Microsoft Excel was used to tabulate and to create histograms. The answers to the open-ended questions were also typed out in the excel-file, and most of them were translated into English due to non-Swedish-speaking researchers involved in the project.

3.3.3 Observations

The observations have been conducted differently for each project. In the LETS GO trials there has been an observation guide developed in English together with research colleagues. The number of observers varied in the different trials and the sessions within each trial. For instance, for all outdoor sessions, all the involved researchers were asked to make observations while, for the indoor sessions, either one or two researchers conducted the observation. For the GeM trials, one trial used a similar observation guide and approach as for the LETS GO trials while the rest of the GeM trials and for the Collboard project the observation was done randomly. The observations were carried out through the whole sessions where observation was one indented data collection method.

All observations have been summarized and the few observations that have been written in Swedish have been translated into English for the non-Swedish researchers involved in the projects.

3.4 Data Analysis Methods

A Thematic approach will be undertaken for the analysis of the empirical data. Two different analyses have been conducted, as presented in the following section. Finally a holistic analysis and discussion has been done based on the results of the thematic analysis together with the Introduction (Chapter 1), Area of Concern (Chapter 2), and Use of Ubiquitous Technologies in Compulsory Education in Sweden (Chapter 3.1).

3.4.1 Thematic Analysis

The thematic analysis model is, as Boyatzis (1998) states, a process that can be used with most, or arguably, all qualitative methods. It is also a process of encoding quantitative data. Using thematic analysis, the researcher is able to use a wide range of different types of material and in a systematic way analyze the data for understanding and interpreting people, situations, events, and organizations in a sensitive and accurate way (Boyatzis, 1998). There are a number of alternative and/or overlapping purposes for using the thematic analysis (Boyatzis, 1998 p.4):

1. A way of *seeing*
2. A way of *making sense* of seemingly unrelated material
3. A way of *analyzing* qualitative data
4. A way of *systematically observing* a person, an interaction, a group, a situation, or a culture
5. A way of *converting* qualitative information into quantitative

Boyatzis (1998, p.4) defines a theme as "a pattern found in the information that at minimum describes and organizes the possible observation and at maximum interprets aspects of the phenomenon". Widerberg (2006) mentions two possible approaches for the

identification of themes: theory based, and empirically based. In Boyatzis' (1998) terms, the former is referred to as deductive approach and the latter as inductive. In the inductively-generated approach, the empirical material and the raw data are the starting point. In the deductive approach, the researcher generates and identifies themes from different theories or prior research. In this study the first analysis will be inductive, identifying themes from the empirical data while the second analysis will be deductive in terms of categorizing the empirical data according to themes based on a theoretical model.

Inductive Thematic Analysis

Due to the large amount of qualitative data in various different forms, an empirically-based thematic analysis was applied as a first analysis. The data-based thematic analysis allows for identifying patterns and similarities from different types of material in order to analyze and understand the material at hand (Boyatzis, 1998). The aim of the inductive thematic analysis is to understand the factors influencing teachers' and students' experience in using mobile and ubiquitous technologies (Salavati & Mörtberg, 2012b). The students' and teachers' experience may affects their perception and acceptance of adopting and using technology in novel ways to support teaching and learning.

As a first step in the analysis process, Widerberg (2006) argues that the material at hand should be sorted. It may be a rough step but important and useful since it gives an overview of the material as well as an initial idea of key patterns and themes. Hence, the researcher will gain a perception of the involved individuals and their lives in the specific context (Widerberg, 2006).

During the process of collecting the data and transcribing the interviews and compiling the survey and the observations, a rich understanding of the students' and teachers' world was gained. This understanding was built based on number of issues reccurring several times throughout the empirical material, resulting in a number of preliminary themes emerging, as illustrated in the figure below (Salavati & Mörtberg, 2012a).

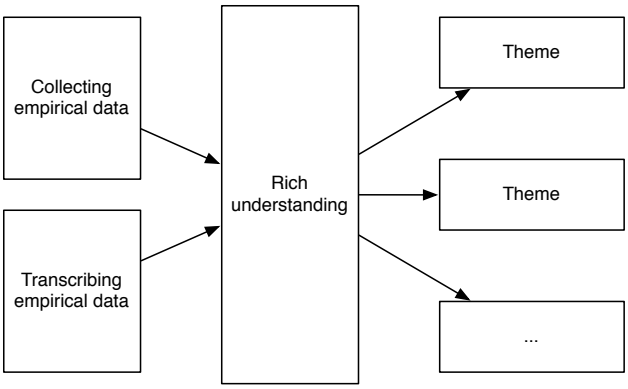


Figure 3.4 The inductive thematic analysis process (adopted from Salavati & Mörtberg, 2012b)

The next step in the analysis was to re-read the empirical material, transcribed with the preliminary themes as guidelines. A coloring schema for each theme was used. When a primary theme was identified in the text it was colored with the specific theme color. During the analysis some themes were changed and the preliminary themes were converted to more definitive themes (Salavati & Mörtberg, 2012a).

Deductive Thematic Analysis
The second analysis of the empirical material is mainly based on themes taken from the Venkatesh et al.'s (2003; 2012) models: Unified Theory of Acceptance and Use of Technology, UTAUT and UTAUT2. The first model consists of four constructs and four moderators influencing the factors affecting the behavioral intention and thereby the actual use (Venkatesh et al., 2003). The second model builds upon the first but adds additional constructs and removes one of the moderators due to the different focus of the UTAUT2 model. The deductive thematic analysis will use the four main constructs of the first model, which is also included in the second model, as themes for analysis of the data. In addition two more constructs from the UTAUT2 (Venkatesh et al., 2012), will be included as themes in order to gain a more comprehensive understanding of the data.

All empirical data were collected without any influence or inspiration of the UTAUT or UTAUT2 models. The themes for the deductive thematic analysis were identified with reference to the UTAUT theories after the transcriptions and compilations of the collected data. The transcriptions and compilations of data were thereafter reviewed and each main construct was marked based on a coloring schema, each construct having a unique color. The marked data from each project was tabulated separately into tables. In the final step after analyzing all three projects separately, a comparison has been done across the different projects, discussing similarities and differences. Further issues concerning the teachers' perception, acceptance and use of mobile and ubiquitous technologies in educational settings which have not been covered by the model will be discussed.

Both models will be presented in Chapter 4. Additionally, the use of the models will be reflected upon in Chapter 7.

3.4.2 Holistic Analysis

Due to the complexity of teaching and learning practices, Soft Systems Methodology, SSM will be applied in this study. SSM is a methodology from the Systems Thinking school, used for understanding complex and ill-structured real-life problematic situations based on a number of models representing the situation (Checkland & Poulter, 2010). The concept of Systems Thinking aims to create a understanding of elements or parts and their relationship and interaction within the whole rather than the properties of the different components (Checkland, 1999; Jackson, 2003).

This study uses the Soft Systems Methodology and specifically Rich Pictures (see Chapter 4 for further details). The pictures were initially drawn on flipchart papers based on related and precious research (Chapter 1 and 2), policy documents (Chapter 3.1), and empirical findings (Chapter 5). Later these were digitalized using sketching applications as well as a diagramming application.

3.5 Ethical Considerations

To ensure ethical issues are complied with, all participants in the trials have given their consent on paper. For students under the age of 15, their parents have given consent for their children to participate, based on an information flyer, and the students are given a different information flyer addressed specifically to them. For students above the age of 15 and under age of 18 the students have themselves given consent, based on information flyers; their parents have also been given information flyers addressed to them. The consent forms

and information flyers followed the ethical guidelines given by the Swedish Central Ethical Review Board.

The consent forms and information flyers consist of a description of the project in focus, what types of data collections will be used and to what purpose. The students and parents are informed that participation in the research aspect of the trial is voluntary and the student can drop out of the research part of the project at any time. Both consent form and information flyer were developed in Swedish and was handed out by the teachers in the class and collected by the teachers. All consent forms have been stored according to the Swedish Ethical Review Board.

CHAPTER 4

Methodological Approaches

The initial section of this chapter will present the deductive thematic analysis, based on the UTAUT model applied to the empirical data. Rich Pictures of Soft Systems Methodology, presented in the second and final section of this thesis, has been applied in order to gain a holistic understanding of the situation bring the empirical analyses and the area of concern together.

4.1 Deductive Thematic Analysis: Unified Theory of Acceptance and Use of Technology

There are a number of models and theories for analyze the use and acceptance of technology, although the variables most technology acceptance models depend on are the behavioral intentions to use an information system and the actual use. There are studies defining and focusing on acceptance as the *intention* of information technology and other studies defining acceptance as the *actual use* while there are also studies measuring both the intention and the actual use. According to Keller (2007) is the Unified Theory of Acceptance and Use of Technology the most elaborated and scientifically-recognized acceptance model.

Venkatesh et al., (2003) developed the Unified Theory of Acceptance and Use of Technology, the UTAUT model, based on eight different models. Description of each one of the models can be found in Appendix A. These eight models have their roots in information systems, sociology and psychology, all with an accounted variance of between 17 per cent and 53 per cent in intended use (Keller, 2007). The UTAUT model could explain 70 per cent of variance according to Venkatesh et al. (2003), performing an empirical study on two organizations.

The eight different models that UTAUT draws upon consist of a total of 32 constructs that in the UTAUT model have been merged into four main constructs and four influencing

moderators (Venkatesh, et al, 2003). The four constructs UTAUT builds on are (1) Performance Expectancy, (2) Effort Expectancy, (3) Social Influence, and (4) Facilitating Conditions (Venkatesh et al., 2003). Table 4.1 presents the constructs with definition as well as the original models. [21]

Table 4.1 Core Constructs of UTAUT, definitions and origins (adopted from Venkatesh et al. 2003)

Construct	**Definition**	**Original Construct and Model**	
Performance Expectancy	"The degree to which an individual believes that using the system will help him or her to attain gains in performance" (Venkatesh et al., 2003, p.447)	perceived usefulness	Technology Acceptance Model, Theory of Combined TAM and TPB
		extrinsic motivation	Motivational Model
		job-fit	Model of PC-Utilization
		relative advantage	Innovation Diffusion Theory
		outcome expectations	Social and Cognitive Theory
Effort Expectancy	"The degree of ease associated with the use of the system" (Venkatesh et al., 2003, p.450)	perceived ease of use	Technology Acceptance Model
		complexity	Model of PC-Utilization
		ease of use	Innovation Diffusion Theory
Social Influences	"The degree to which an individual perceived that important others believe he or she should use the new system" (Venkatesh et al., 2003, p.451)	subjective norm	Theory of Reasoned Action, Technology Acceptance Model 2, Theory of Planned Behavior, Theory of Combined TAM and TPB
		social factors	Model of PC-Utilization
		image	Innovation Diffusion Theory
Facilitating Conditions	"The degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system" (Venkatesh et al., 2003, p.453)	perceived behavioral control	Theory of Planned Behavior, Theory of Combined TAM and TPB
		facilitating conditions	Model of PC-Utilization
		compatibility	Innovation Diffusion Theory

Beside the four constructs there are also moderators: gender, age, experience, and voluntariness of use, which indirectly influence the intention via the four constructs as illustrated in Figure 4.1.

[21] Appendix A shortly describe the original models and the full references for each model can be found at the end of the bibliography chapter

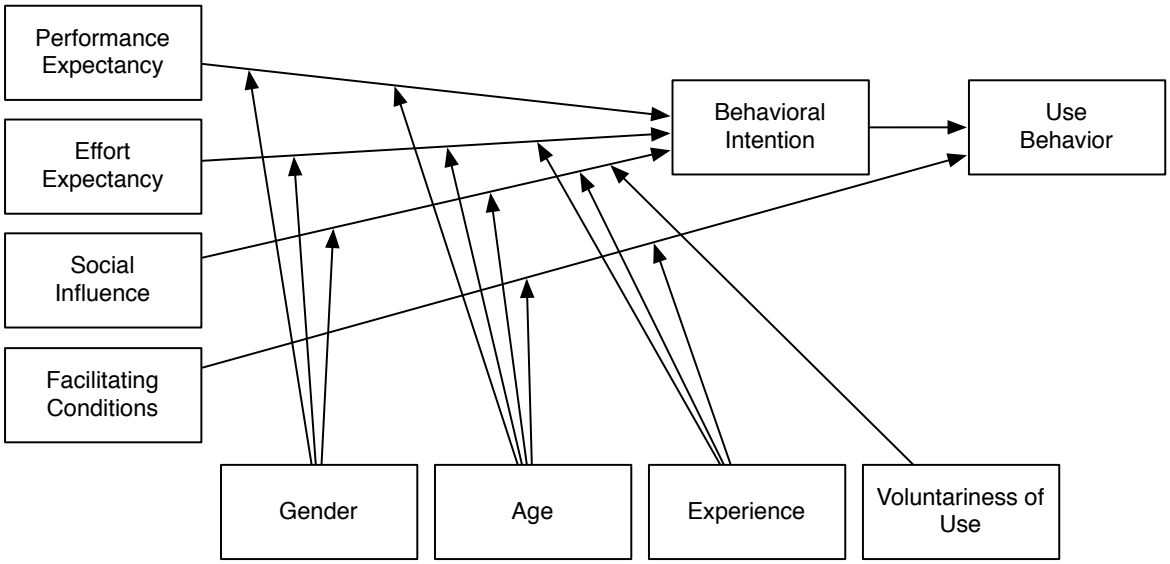


Figure 4.1 The Unified Theory of Acceptance and Use of Technology Research model (adopted from Venkatesh et al., 2003)

Venkatesh et al. (2003) do not further define the different moderators, although Moore and Benbasat (1991, pp. 195) have, within the Innovation of Diffusion theory, defined the moderator Voluntariness of Use as "the degree to which use of the innovation is perceived as being voluntary or of free will" (Venkatesh et al., 2003, p.431).

Despite the comprehension and extent of the model, it has been criticized by, among others, Straub (2009), mainly arguing for the lack of validation as it has not been used since its publication to a great extent in the research literature. In relation to educational settings Straub argues that the UTAUT model does not cover the complexities and other influences specific for the educational setting. The model does not cover the influences of technology change on relationships with students and teachers, as the educational environment is different from the business environment despite sharing a few similarities. Straub (2009) further argues that the UTAUT model is one of the few models that considers the voluntariness or willingness of the users towards new technology. However, when studying the intention and behavior of the use of technology in a mandatory environment, the model does not completely measure acceptance, since the users do not ultimately have a choice in accepting the technology. Straub (2009) believes the model captures and covers much important and valuable information on intention and use of technology even if needs to be tested further and additional research is needed for understanding how UTAUT can be applied in educational institutions and informal learning settings. However, for this study the constructs of the model is still valid as it will give an initial understanding of what influence the acceptance and perception of use of mobile and ubiquitous technologies in educational setting. It will thereby create an understanding of influencing factors for novel use as well as indicating the challenges for accepting, adopting and using mobile and ubiquitous technologies in novel ways in everyday education.

In a more recent publication, Venkatesh et al. (2012) extended the original UTAUT model, adding additional constructs and relationships to the model and developing UTAUT2. Venkatesh et al. (2012) argues that the extended model is mainly aimed towards a customer-use context rather than consumer use as the intention of the original UTAUT

model. The UTAUT2 model includes three added main constructs: (1) Hedonic Motivation, (2) Price Value, and (3) Habit. The definition of the added constructs can be seen in Table 4.2.

Table 4.2 Added Core Constructs of UTAUT2

Construct	Definition
Hedonic Motivation	"The fun or pleasure derived from using a technology" (Venkatesh et al., 2012, p.161)
Price Value	"The consumers' cognitive tradeoff between the perceived benefits of the applications and the monetary cost for using them" (Venkatesh et al., 2012, p.161)
Experience and Habit	"Experience […] reflects an opportunity to use a target technology and is typically operationalized as the passage of time from the initial use of a technology by an individual. […] Habit has been defined as the extent to which people tend to perform behaviors automatically because of learning" (Venkatesh et al., 2012, p.161)

The extended customer-oriented UTAUT model has also removed the moderator Voluntariness of Use and the relations have been modified. Figure 4.2 illustrate the UTAUT2 model.

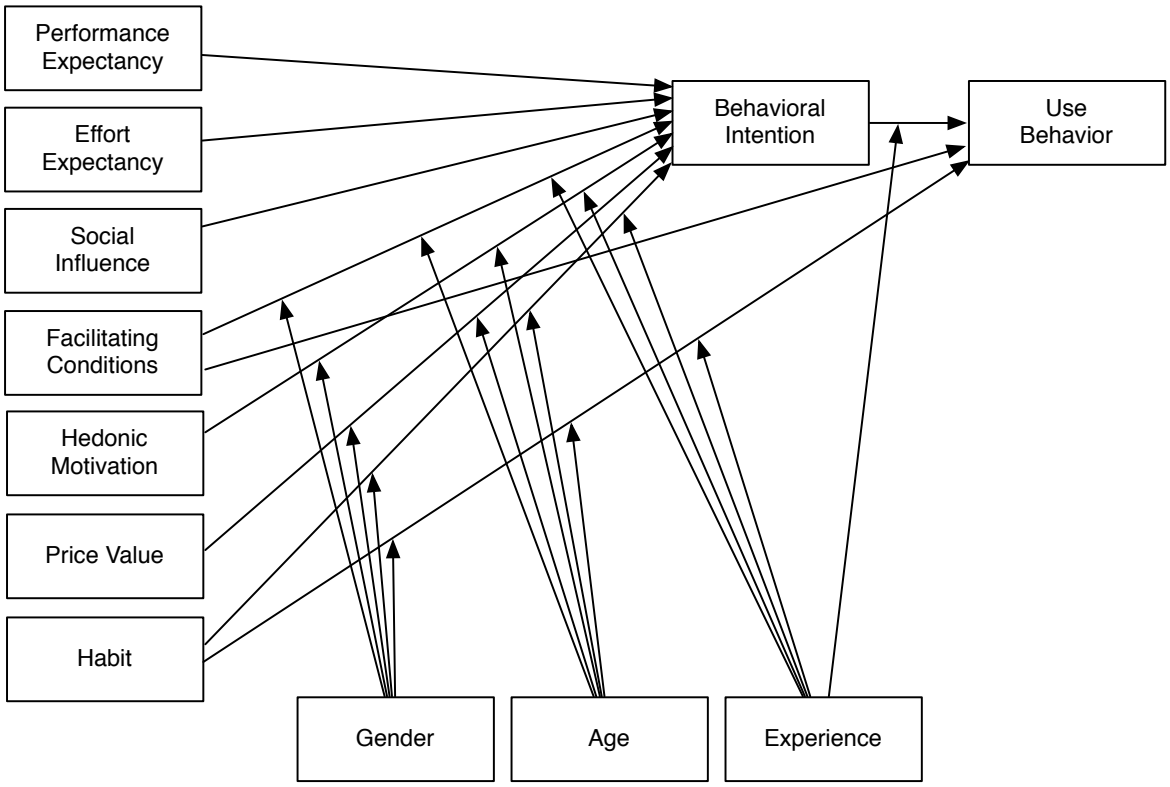


Figure 4.2 The Unified Theory of Acceptance and Use of Technology 2 Research Model (adopted from Venkatesh et al., 2012)

The Behavioral Intention is defined as the critical predictor in the use of the technology (Venkatesh et al., 2003). Venkatesh et al. (2003; 2012) argue that the Performance Expectancy in most cases is the determinant factor for behavioral intention. Further the Hedonic Motivation, enjoyment, is considered a critical factor and an important driver for technology use and is thereby a complement to the UTAUT's strongest construct (Venkatesh et al., 2012).

For the deductive thematic analysis in this study, the four original constructs, one of the moderators, Voluntariness of Use and two of the UTAUT2 constructs, Hedonic Motivation and Habit constructs has been considered as themes. This is illustrated in Figure 4.3. The deductive thematic analysis is mainly built upon the original UTAUT model that focuses on the consumers' perception towards use of technology. However, in the focus of this study the students are not considered as consumers but are considered as users in school education, which in Sweden is compulsory. Moreover, have the Hedonic Motivation and Habit combined with the moderator Experience been added as themes. The construct of Habit and the moderator Experience have been combined as they are considered to relate to one another (Venkatesh et al., 2012). The Price Value has not been included as the customer perspective of the costs for using technology is not relevant for the aim of this study. The figure also illustrates the influencing relations according to the UTAUT2 model (Venkatesh et al., 2012).

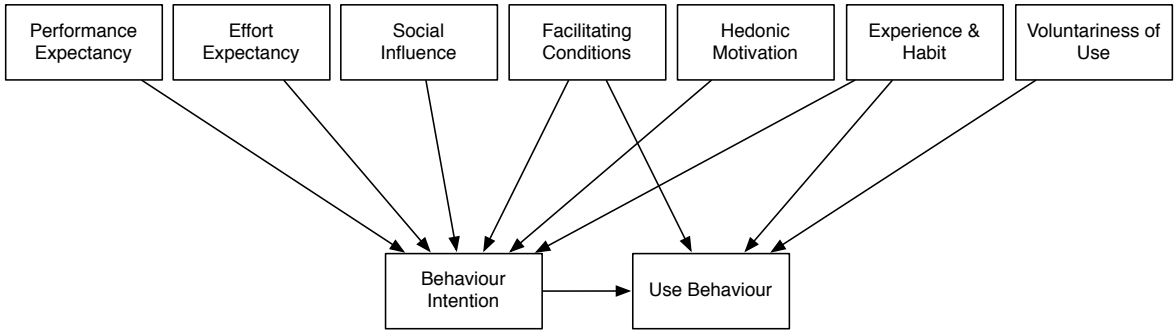


Figure 4.3 The Unified Theory of Acceptance and Use of Technology Thematic Analysis (adopted from Venkatesh et al., 2003; Venkatesh et al., 2012)

Each project was analyzed based on each one of these themes. Due to ethical considerations and the confidentiality of the participant, the moderators of Gender and Age have not been taken into consideration in this analysis, and Experience has been combined with the Habit construct. This analysis will, contrary to Venkatesh et al.'s 2003 study, be qualitative rather than quantitative. Hennington et al. (2009), in a study understanding the nurses' use of electronic medical record system, have used the UTAUT model with qualitative data. The empirical material of that study is based on semi-structured interviews derived from Veknatesh et al.'s 2003 survey instrument. As mentioned in Chapter 3.4.1, subsection Deductive Analysis, the empirical data in this thesis and for this analysis has been collected without any influence from the UTATU or UTAUT2 model and without technology acceptance as a main aim. However, in order to understand the perception and attitude of the teachers towards the use of technology, this model has been used in the analysis of the collected data.

4.2 Holistic Analysis: Systems Thinking and SSM

The whole is greater than the sum of its parts, is a well known statement realted to Systems Theory, and thus Systems Thinking as we know it today (von Bertalanffy, 1972). The biologist von Bertalanffy, one of the founders of systems thinking, argued in the late 1920s that "the fundamental character of the living thing is its organization, the customary investigation of the single parts and processes cannot provide a complete explanation of the vital phenomenon" (von Bertalanffy, 1928:64, in von Bertalanffy, 1972, p.410). He argues that in order to understand the whole we need to know the parts and the relations between them: it is then we first gain a higher understanding of parts.

Systems Thinking can be considered as the process of understanding how things influence one another within a whole: the concept is more than thinking of, talking about, and acknowledging systems, and its importance (Forrester, 1994). The notion of systems thinking does not refer to "things" but is a way of perceiving and understanding the world. Flood and Jackson (1991) argue the concept of system in systems thinking is "a complex and highly interlinked network of parts exhibiting synergistic properties" (Flood & Jackson, 1991, p. 4). Another definition of system is coined by Checkland (1999), defining the concept as representing a set of elements or components connected to one another to create a whole; the representation of the properties of the whole rather than the properties of the components; the whole relying on the elements and their interactions as a unit giving meaning to the parts and their interactions (Jackson, 2003).

Different scholars have categorized Systems Thinking differently, based on their worldviews and techniques for viewing a system. Two of the most common categories consist of "Hard Systems Thinking" and "Soft Systems Thinking." Checkland (1999) distinguish between Hard- and Soft Systems by claiming Hard Systems Thinking to be defined within Systems Engineering and Systems Analysis and hence having its starting point in "structured" problems, with the systems objectives being well defined and consistent. On the contrary to Hard Systems Thinking, Soft Systems concerns problem situations rather than problems as such and thereby has its starting point in unstructured, ill-defined social systems. Soft Systems use and apply systems ideas from hard systems in soft situations trying to establish and structure debate in order to improve a problematic situation (Checkland, 1999).

This thesis has undertaken a Soft Systems Thinking approach as the aim of this study is to understand the parts, viewpoints and interactions within a complex problematic situation (Checkland & Poulter, 2010; Jackson, 2003).

Soft Systems Methodology

In the 1970s Peter Checkland and colleagues developed Soft Systems Methodology, SSM, at University of Lancaster, Systems Department (Checkland, 2011; Reynolds & Holwell, 2010). Checkland defines SSM as a methodology for setting out the principles of use of methods for ill-structured problem situations where not only goal-seeking and "what" and "how" questions are important but also the maintenance of relationships between the parts and between the part and the whole (Checkland, 1999). It is an action-oriented-inquiry approach for understanding and analyzing complex problematic situations of all kinds. The users in problematic situations are to learn their way of understanding and finding out about the situation and then take action to improve it (Checkland & Poulter, 2010). Mingers and Taylor (1992) claim that the essence of SSM can be identified in its name: *Soft* implying fuzzy, ill-defined situations that contain different perceptions and views; *Systems* meaning that a holistic approach is used for studying systems and their wider context, and *Methodology*

means using a structured approach with a number of ordered activities. They further describe the heart of SSM to be gaining a greater understanding of other peoples' views and perspectives, and the fundamental premises of SSM to be the importance of different perspectives and Weltanschauung[22] (Mingers & Taylor, 1992). As Mingers (1986) argues in a report, thinking without use of SSM might be just as productive and successful as thinking with SSM, although using SSM provides guides and a framework for handling one's thoughts in an organized matter.

As we are dealing with real life it is more complex than that; many situations should not be seen as a problem that has a solution, thus eliminating that problem forever. The complexity of real-life problem situations lies in the fact that no problem is ever static; it always contains several interacting perceptions as people in that situations have different interpretations of the "same" reality; they have different world-views of the same "problem" (Checkland & Poulter, 2010). By using SSM, a number of models that are compared to the real world will be constructed. These models represent "human activity systems" and aim at questioning the perceived "real world" and contributing to debate about change, rather than being a single blueprint of the world. The aim is not to be limited to particular problems in the real world but to gain an understanding of how different actors may perceive various aspects to be problematic within a situation (Checkland, 2000; Jackson, 2003; Jackson & Keys, 1984).

SSM has been represented in several models, of which the initial seven-stage model (Checkland, 1999; Checkland, 2000; Vidgen et al., 2002; Stowel & Welch, 2012) and the SSM Learning Cycle, illustrated in Figure 4.4, have been the most frequently occurring.

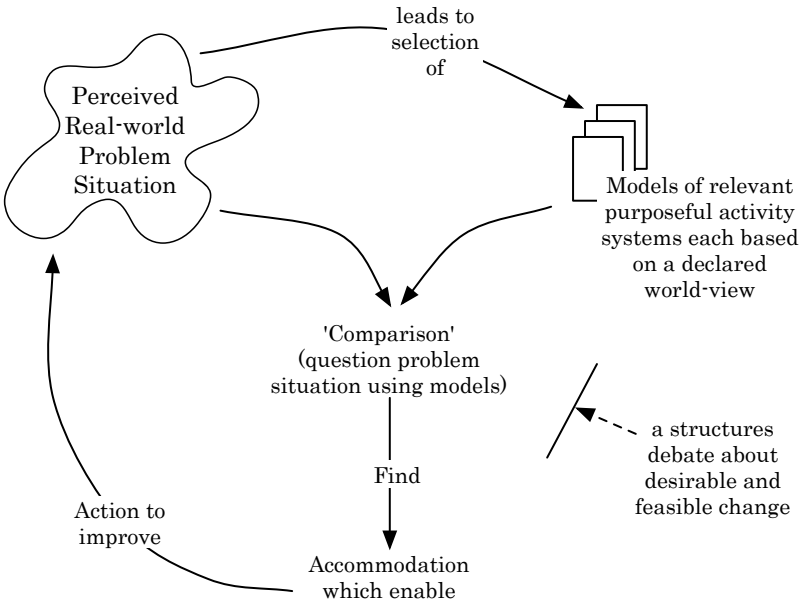


Figure 4.4 The Learning Cycle of SSM (adopted from Checkland, 2000)

Checkland (2000) defines the process of SSM as going from identifying and finding out about a perceived problematic situation up to taking action for improvement: a cycle where taking actions to improve the initial situation will lead to changing the situation to a new situation and, thereby, a potential need for the process to start again. The model consists of

[22] Weltanschauung is the German word for world view, philosophy of life, etc., initially coined by Churchman (1970) in his book 'The Design of Inquiring Systems' as referenced by Jackson (2003)

four phases: (1) finding out about the real-life problematic situation, (2) making purposeful activity models of relationships based on a explicit worldview, (3) questioning the real, perceived situation based on the models with the aim to find desirable and feasible changes and (4) taking action to improve the situation (Checkland, 2000; Checkland & Poulter, 2006; 2010; Checkland & Winter, 2006; Somerville et al., 2006; Mirijamdotter & Somerville, 2009).

The model-building of SSM consists of gathering data and building 'rich pictures' of the situation, and making models of purposeful activity systems based on different worldviews, i.e., Weltanschauung. The different worldviews are embodied in 'root definitions' where each one is further developed into a conceptual model representing one side of the reality, one worldview (Jackson, 2003). In the following, this study expands on just the Rich Picture technique, in order to gain a deeper and fuller understanding of the complexity of the situation of adopting novel use of mobile and ubiquitous technologies in everyday compulsory school education.

4.2.1 Rich Pictures

The Rich Picture technique is one of the most frequent and most successful within SSM (Mingers & Taylor, 1992; Jackson, 2003), where the aim is to capture a rich, open representation of the situation, not imposing a rigid structure of the elements or using systems terms (Vidgen et al., 2002; Jackson, 2003; Checkland & Poulter, 2006; Stowell & Welch, 2012). The Rich Picture aims to gain understanding of a problematic situation by capturing entities, structures and viewpoints within the situation as well as identifying the ongoing processes, the current known and potential issues (Checkland & Poulter, 2006; Jackson, 2003)

Checkland and Poulter's reasoning behind Rich Picture is the complexity of human situations and the interaction of multiple worldviews and interacting relationships. They argue that the best way to show complexity is through pictures, and the situation can be taken in as a whole while the multiple relationships are illustrated (Checkland & Poulter, 2006); it enables a holistic thinking about the situation (Checkland, 2000).

Within the Rich Picture, the cultural, social and political aspects of a problem should be recognized, enabling expression of the interrelationships in a problematic situation. The different roles should be reflected upon, such as who caused the study to take place; who wishes to do something about the problematic situation; and who has an interest in that problematic situation (Checkland & Poulter, 2006; Jackson, 2003). Checkland emphasizes roles rather than people, as a person can have several roles and, further, a person can change or abandon a role (Checkland & Poulter, 2006). Also, as mentioned above, the problematic situation can be looked at from various different perspectives in order to become holistic (Jackson, 2003). The roles, formal or informal, say much about the culture of the way the people within the roles look at the world. Further aspects are norms defining the various expected behaviors associated with the various roles, and values are standards to judge the performance of the behavior-in-role. The roles, norms and values create the social context of humans and can either endure or change over time and situations (Checkland & Poulter, 2006). The political aspect of the problematic situation is to define how power is obtained and used. Checkland and Poulter (2006) argue that there is an unavoidable political dimension within any human affair involving action by people who can have different worldviews and interests. The authors use the concept of commodity for expressing how the

power is expressed in terms of being obtained, used, defended, passed on and relinquished (Checkland & Poulter, 2006).

In this study, SSM's Rich Pictures will be used for analyzing and discussing the problematic situation of what influences the novel use of mobile and ubiquitous technologies in everyday teaching and learning practices. As applied by Mirijamdotter and Somerville (2009), the Rich Pictures in this study will not be used in its traditional manner but, rather, to illustrate different perspectives and worldviews within the problematic situations in order to analyze and discuss, on a holistic level, the novel use of mobile and ubiquitous technologies in educational practices.

CHAPTER 5

Empirical Analysis

This chapter will present the findings of the empirical analysis of the three local projects; GeM, LETS GO and Collboard presented in Chapter 3.

The first section will present the results of the analysis of the students' and teachers' experience of using mobile and ubiquitous technologies in their learning and teaching settings. For this analysis an inductive thematic analysis approach has been applied. The second section includes an analysis by means of a modified version of the Unified Theory of Acceptance and Use of Technology model, with the aim of understanding the perception and acceptance of teachers' use of mobile and ubiquitous technologies in order to understand influencing factors for novel use of mobile and ubiquitous technologies. The final section will bring the results of the empirical analyses together in a Rich Picture.

5.1 Students' and Teachers' Experience of Using Mobile and Ubiquitous Technology

The thematic analysis has been used to explore the experiences teachers and students have had using mobile and ubiquitous technologies. As an outcome to the analysis, five themes were identified: (1) fun, (2) collaboration and discussion, (3) enhanced learning, (4) advantages and (5) disadvantages. Additional statements, such as software development, the design of the activities, etc., have not been included in the analysis as they are not the focus of this study.[23]

This section has been divided into two subsections presenting the perspective of the students' and teachers' separately, and, in a final subsection, there is a discussion of both student's and teachers' experiences, based on the two main themes.

[23] See Research Scope and Limitations, Chapter 1.2

5.1.1 Students' Perspective

Having Fun
Fun was one of the strongest experiences identified within the analysis: students frequently mentioned this in reference to their experiences in various contexts and discussions. One student in the GeM project believed that most of the students had fun participating in the trial:

> *It has be fun for most of us. // GeM student*

Students from the Collboard project also mentioned fun in the open-ended question in the survey. They expressed it in the following way:

> *It is a very fun way to learn […] you learn more than usual. // Collboard student*

> *It was a fun way to do math. // Collboard student*

To have fun and to enjoy the activity is considered important by the students; they believe that they learn more when they have fun.

Enhanced Collaboration and Discussion
Collaboration and Discussion is the second theme identified and many of the patterns were seen in the observations. The level of discussions within the different projects and trials varied considerably. In the LETS GO project there were cases where the students discussed and collaborated effortlessly between themselves and with the teachers, and, in other cases, there were the students who needed to be driven and supported by teachers and Swedish-speaking researchers to help them carry out their discussions in order to reach a conclusion. This was mainly in indoor settings but the increased interaction between the students could also be seen when the students had outdoor activities, especially in the GeM project where most of the activity was conducted outdoors with mobile phones. The students participating in the LETS GO and GeM projects believed collaboration was valuable and had enjoyed collaborating with classmates, and particularly with classmates they do not usually work with:

> *It was fun to collaborate with others for once. // LETS GO student*

> *We thought together pretty much. // GeM student*

In the Collboard project the discussions and collaboration were carried out in a different way and the students had to discuss with one another in order to reach a common final solution of the task they have been given and had solved individually:

> *To be able to discuss the answers and together come up with a solution that everybody understands. // Collboard student*

> *Everyone takes part in the discussion. // Collboard student*

The scaled-based questions from the Collboard survey also identified collaboration. Out of twelve students, nine agreed on their being able to discuss more with their classmates during the Collboard activity than in regular math classes. Seven out of twelve students agreed that during the activity they had been more able to discuss with their teacher compared to regular math lessons.

Positive Impact on the Learning
One of the experiences the students had when using mobile and ubiquitous technologies in these projects is that they have learned more. Three of the students said:

[I] learned a lot. // Collboard student; LETS GO student

You learn a bit more. // GeM students

Enhanced learning as an outcome was also mentioned in the Collboard project. In the open-ended part of the survey that had no direct question about learning issues, the students exemplified about enhanced learning by writing:

You learn how to reach a solution and you will remember it. // Collboard student

You can learn from one another in a good way.// Collboard student

The students participating in the projects explained that their use of technologies has resulted in fun, collaboration and discussion – all factors they believe have had an influence on their learning.

Opportunities and Benefits

The main advantages that students have experienced in using mobile and ubiquitous technologies have been those discussed above. Besides having fun, increased collaboration and discussion, better understanding and enhanced learning, the ease of use of the technology has been one advantage that the students have experienced.

Drawbacks and Difficulties

The disadvantages the students experienced within these projects mainly concern technology as tools. In the Collboard project, for instance, even though eight out of ten students who had used the Collboard software agreed that the software was easy to use, most students also said that the digital pens used for the individual part of the task did not work satisfactorily. Further, some students experienced some problems in the LETS GO and GeM project were mobile phones were used, mainly concerning losing contact with the network, causing difficulties in finalizing their assignments. Although the application and the mobile phone as such were easy to use, one student reported that

When it went really bad with the mobile phones, and it was wrong, we continued with our guessing and that was pretty good. // GeM student

It could also been seen during the observations that some students, mainly in the LETS GO project, were very cautious and insecure when they used the technology, especially the sensors, but they became more comfortable as time passed and they got used to the tools.

5.1.2 Teachers' Perspective

Having Fun

Teachers also talked about students having fun and enjoying participating in these trials and using the technology as tool for learning. This was explicitly mentioned by the LETS GO and GeM teachers. As one of the teachers put it:

I think it is very good to use modern technology to help students to learn better, and it can also help motivate students. They think it is more fun. //LETS GO teacher

The teachers argued an essential issue in learning is for the students to have fun and enjoyment. It keeps the students interested and motivated.

Enhanced Collaboration and Discussion

For the teachers, collaboration and discussion is an important part of learning and they also want to be able to create spaces for more discussion in order to enrich knowledge creation for the students. A number of teachers explained that collaboration, with the support of mobile and ubiquitous technologies, often leads to discussions that are more difficult to achieve in traditional settings. The Collboard teachers explained this when they were asked whether the interactive whiteboard, used for representing the students' solutions, did indeed support discussions:

> *[It] forces the students to collaborate and discuss different methods in solving the problem […] they have to have those discussions, that is the way they learn. // Collboard teacher*

> *It promotes even more collaboration both between teachers and students and between students where it could contribute to knowledge by learning from each other. // Collboard teacher*

A GeM teacher mentioned discussion as one factor when asked how the project could be further developed:

> *Discussion is what we want to achieve […] it creates new knowledge as they have to explain to one another and hear explanations from each other. // GeM teacher*

Discussing and collaborating is a way of understanding something and generating new knowledge. From the teachers' perspective, interaction, collaboration and discussion are considered necessary for the students' learning, and this is difficult to achieve in traditional settings but is enabled by the support of technologies.

Positive Impact on the Learning

As mentioned in the collaboration and discussion theme, the teachers believe that learning is enhanced when students collaborate and discuss, together and with the teachers. A LETS GO teacher mentioned technology as enabling stimulation in relation to the students learning:

> *It is more stimulating learning this way. // LETS GO practicing teachers from the teacher education program*

Opportunities and Benefits

Other advantages experienced by the teachers, beside the themes mentioned above, are the opportunities that mobile and ubiquitous technologies bring to educational settings. This could be exemplified by a LETS GO and a GeM teacher saying:

> *Children use different senses when they learn, therefore it is good to use different media […] more exciting and fun compared to paper and pencil. // LETS GO practicing teachers from the teacher education program*

> *[It is] important that schools modernize their way of educating [to bring in] new ways to teach for the teachers. //GeM teacher*

The ease of use was also mentioned as an advantage in the use of the technology. The teachers expressed this both in relation the students and themselves preparing for lessons:

> *…absolutely, the students were feeling more and more comfortable by the end. // Collboard teacher*

> *Just put the problem in the software and you are ready to go. // Collboard teacher*

Prospective teachers, teachers-to-be, in the LETS GO trial were mainly positive about using technology in teaching when they become qualified teachers. When some of these

students were asked in the survey what they believed the reason of the positive attitude towards the use of technology had been, they replied:

> *[It] enriches everyday teaching. // LETS GO practicing teachers from the teacher education program*

> *To keep the children interested we need to keep up with their interest to get the education they respond to. // prospective teachers in the LETS GO trial*

Teachers in GeM and Collboard stated the following in their interviews:

> *... the idea of being outside and to truly experience what you are doing, to do tasks practically and to reach a better understanding. It should not be just facts but to gain an understanding of the whole. // GeM teacher*

> *All the students gained so much from it […] it is okay if you have not solved the task since you can still contribute with something useful […] all students can contribute. // Collboard teacher*

The teachers believe that the advantage of the technology is that the students become more active in their learning and they gain a better understanding of what they are doing as well as giving the opportunity to all students to participate and contribute.

Drawbacks and Difficulties

The main disadvantages the teachers mention, beside the costs, are the lack of time, training, comfort in use of the technology as well as the class sizes. Just as for the students, who became more comfortable with the technology when given more time to work and get familiar with it, so it is for the teachers. This concern was mentioned by one of the GeM teachers:

> *It was just that we were not familiar enough with this – how the mobile phone functions and how to proceed with the various tasks. // GeM teacher*

The lack of time and training was expressed by many teachers. The teachers and student teachers argued that, for technology to be used and adopted in educational practices, education and training is crucial:

> *Practice is needed to get used to and comfortable with the technology. // GeM teacher*

> *It was easy when we learned it […] if we had more time we would have learned more[…] it is more difficult than it seems. // LETS GO practicing teachers from the teacher education program*

A concern of the teachers, apart from the technology per se, was class size. Another concern was about the students playing with the technology instead of doing what was asked of them and to focusing on those tasks. A Collboard teacher said:

> *With a full class, even if you manage to create a discussion, it will still be difficult to make everyone active. // Collboard teacher*

The uncertainty of how to handle large classes apart, teachers were also concerned about the lack of knowledge, comfort, training and education in how to use the technologies in everyday practices.

5.1.3 Summary and Conclusion of the Inductive Analysis

The experience of students, teachers and prospective teachers in using mobile and ubiquitous technologies in the three projects, GeM, LETS and Collboard, has been identified in five themes: (1) fun, (2) collaboration and discussion, (3) enhanced learning, (4) advantages and, (5) disadvantages, as illustrated in Figure 5.1.

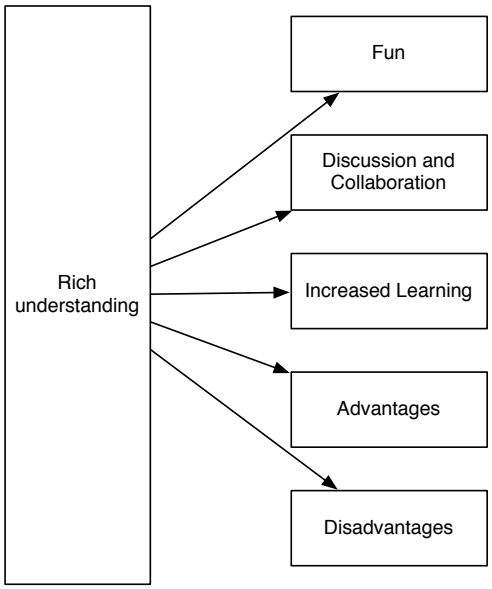


Figure 5.1 The inductive thematic analysis themes (adopted from Salavati & Mörtberg, 2012b)

The experience of the students and the teachers affects their perception, attitude and what they believe to be positive or/and not positive in the use of mobile and ubiquitous technologies which is an issue that may influence their adoption.

The experience of the participants has been largely dominated by positive experiences. By introducing technologies to the educational environments, both teachers and students believe that the students have been given opportunities to collaborate and to discuss, enhancing their learning by fostering participation and active learning. The experienced added value by the teachers' and students' has been based on their experience of mobile and ubiquitous technologies; having fun while learning, collaboration, discussion and enhanced learning. Both teachers and students believe having fun and enjoyment are important factors for keeping students motivated and interested in learning. Increased collaboration and discussion have been other factors that have created opportunities to enhance their learning and understanding of a specific topic, as they discuss and collaborate with peers, teachers and the whole class on a different level. To use technology to create space for these kinds of collaboration and discussion, the teachers argue that all students can actively contribute and participate in the discussion regardless of knowledge level, learning abilities or how far they have reached in finalizing a task. The students themselves believed that everyone learned and understood better. Further, an added value has been the ability to work more practically and in an outdoor setting, which enables the students to enhance their learning and understanding.

The teachers and prospective teachers mention the importance of modernizing education and being able to relate to the students' daily lives. Besides linking to the students' everyday setting, the use of mobile and ubiquitous technologies is experienced as bringing new opportunities to the educational setting in terms of the enrichment of everyday learning through, for instance, new ways of teaching, despite a number of challenges. The participants mainly affected by the challenges are the teachers. The teachers' main concerns, beside the cost and availability of the technology, are the lack of proper education and training in using the technology and the lack of time. What further concerned the teachers were the large class sizes, as it is a challenge to engage and actively involve all students in

discussions. Disregarding the general issues around the technology, the teachers expressed the importance of having reliable and sustainable technology, which, together with education and training, influences the comfort and confidence in actually using the technology.

The challenges the students mainly encountered were problems that may always occur when implementing and using technologies. In the Collboard project, the text written with digital pens was difficult to read when transferred to the whiteboard, and in the GeM and LETS GO project the students encountered difficulties in connecting to the GPS (some students believed that standing on a rock to get higher up would help them get better connection). Beside the more technical issues, the students and the teachers generally found the technology easy to use; they were able to overcome the challenging issues and become more comfortable with the technology, which could be due to their familiarity with and use of technology in their everyday life.

This thematic analysis indicates positive features and added value with the use of mobile and ubiquitous technology as well as challenges that need to be considered and further addressed. The challenges that mainly the teachers expressed leave a gap for further analysis in order to understand their viewpoint about actually using mobile and ubiquitous technologies as supporting tools in their teaching, as presented in the following section.

5.2 Teachers' Perception and Acceptance of the Use of Technology

To understand the perception and acceptance of teachers of mobile and ubiquitous technologies in educational settings, the Unified Theory of Acceptance and Use of Technology and the extended UTAUT 2 have been used. Parts of the models' pre-defined categorizations, as presented in Figure 4.3 will be used for the analysis based on empirical data from GeM, LETS GO and Collboard. The categories of the model, derived from Venkatesh et al (2003; 2012), consist of six constructs: (1) Performance Expectancy, indicating the degree to which a user believes that the systems will help in improving performance; (2) Effort Expectancy, indicating the degree of ease of use; (3) Social Influences indicating how important the user believes that others believe in its use; (4) Facilitating Conditions indicate the importance of organizational and technical infrastructure to support the use; (5) Hedonic Motivation indicates the enjoyment and pleasure of use; and (6) Habit and Experience indicate the extent to which the performance becomes automatic through learning and repeated use (Venkatesh et al., 2003; 2012). Further, one moderator is used from the original model: Voluntariness of Use, which indicates the degree to which the user uses the system voluntarily. The identified themes will be presented for each project.[24]

5.2.1 GeM

GeM was a project within the field of mathematics, namely geometry, where mobile phones were used in order enhance collaboration and discussion among students in an outdoor setting. In this thesis, the first and the third iteration of the project has been included. In the first GeM iteration in 2009 three teachers participated while in the third iteration in 2010/2011 no teacher was actively involved.

[24] The tables with the constructs and the quotes from the collected data can be found in the appendixes

Performance Expectancy

Within the first construct, performance expectancy, it was found that the teachers believed that with use of technology they are able to create spaces for discussion and thus achieve greater understanding. One teacher argued that these kinds of discussions, where the students have to explain something to their peers and get other things explained to them, leads to new knowledge:

> *Discussion is what we want to achieve […] [it] creates new knowledge as they have to explain to one another and hear explanations from each other*

Further, the teachers explained that the students gain a better understanding and better comprehension when performing tasks outdoors, which was the case in the GeM project.

Effort Expectancy

In relation to effort expectancy, the teacher with less teaching experience considered the technology difficult to understand for them as pedagogues while one of the others did not think the technology to be difficult to understand

Social Influences

All three teachers mentioned that the students wish for, appreciate and are motivated by using technology in educational settings:

> *The kids will appreciate it.*
>
> *The students want this challenge.*
>
> *Students will be motivated and think it is exciting.*

The teacher with the greatest teaching experience believed it is important for schools to modernize the way in which education is conducted in schools.

Experience/Habit

The teachers that participated in the first iteration of the project were involved throughout the design process of that activity. The trial was conducted with three schools. Two of the teachers with the greatest teaching experienced in terms of years were both teachers in secondary schools while the third teacher with less teaching experience was teaching in a primary school. The working experience of the teachers varied between 7 and 35 years. The one who had taught the longest had some experience in the use of technology in teaching and has also participated in a few research projects involving mobile phones and robots. The other teachers had not had much experience in the use of technology apart from use of the interactive whiteboard as a conventional whiteboard, in some cases showing video and pictures, and use of computers in a traditional manner.

Voluntariness of Use

What was also mentioned by the GeM teachers, mainly those teachers with greater teaching experience, was the importance of various factors that influenced the voluntariness of use of the technology. One teacher argued that teachers will gradually learn how to use the technology and the focus will then be switched to the students' learning and will reach the desired discussions:

> *One will learn how to use the technology gradually and then these discussions will be easier to achieve and the focus will be on what one intends and not on learning how to use the technology.*

This teacher continues by arguing that if for half of the groups in a class the technology is failing, the teachers won't use the technology. There might be engaged and driven teachers who find some way of solving the problems but if the technology is going to be commonly used it is very important that the technology actually works as intended:

Everything working smoothly is the key for this approach to be used by all teachers.

This is also mentioned by one of the other teachers, who said that they need the technology to be easy to use and be user-friendly so that they can borrow the equipment and work with it.

5.2.2 LETS GO

The LETS GO project focused on environmental science and ecology. The project, which consisted of several trials with different participants, used mobile technology, wireless Internet and sensors enabling students to capture, analyze and reflect on data they collected in both an outdoor and indoor setting. Within the LETS GO project, neither of the teachers from the schools taking part participated in the collection of the empirical data. The teachers' perspective in the LETS GO project is based on the trial conducted with the teacher education program at Linnaeus University during Spring 2011. The participants in the trial consisted mainly of prospective teachers, in training, and two already-practicing teachers who were taking additional courses at the university.

Performance Expectancy

The already-practicing teachers argue there is a need for a combination of both traditional teaching and the use of technology.

[We] need both traditional and technology – need, need to combine them both. Take good parts of both. // practicing teacher

One teacher said using technology is a stimulating way of working and convenient since students use different senses for learning.

It is more stimulating learning this way […] children use different senses when they learn, therefore it is good to use different media. // practicing teacher

They further believe that getting into the routine of using technology simplifies their work as they can, for instance, use the same template for recording student progress for all the students.

While prospective teachers could not relate to the students in the same way as the practicing teachers, when they were given an example of how mobile technology could be used in physical education, to measure heart rate, and/or for activities such as orienteering, they found it intriguing and could easily relate to it.

Effort Expectancy

It was found that the participants in general thought using the technology would be a bit difficult. The prospective teachers thought the mobile phones were the most challenging part but they believe it is easy for their generation to understand the technology and also to teach it to others:

Mobile phones were the hard part. // prospective teacher

[It is] easy for our generation to understand and easy to learn about. // prospective teacher

For the practicing teachers, they also mentioned that, in addition to the mobile phones, the computers were also difficult to use, as one teacher explains:

> *Computers and mobiles were difficult to use since we have not really had it in our education. // practicing teacher*

What the practicing teachers appreciated were the training sessions in use of the sensors and mobile phones before going on the outdoor sessions. They said it would have been even better if they had had more time since they then would have learned to use the technology better and become better at using it.

Social Influences

The prospective teachers and practicing teachers placed great emphasis on the students in relation to the use of technology in educational settings. The informants believe the students in the schools would like to work this way and consider it fun and exciting as it is something that comes naturally to them. The prospective teachers believe that mobile and ubiquitous technology is familiar and that it is important keep up with the interests of the children and thereby keep them interested in their education.

> *To keep the children interested, we need to keep up with their interests in order to give them the education they can respond to. // prospective teacher*

> *Children would think this was exciting, to do this, to work this way. // practicing teacher*

External factors such as evolution in education are mentioned by the practicing teachers, who say that education is moving towards using mobile and ubiquitous technology:

> *It is not about whether we like it or not, evolution is moving in that and we have to learn. // practicing teacher*

The practicing teacher also explain their own children influencing their view and use of mobile and ubiquitous technologies:

> *My son is 14 years old and I am asking him all the time how to make this and how to to that […] compared to me he can alot. // practicing teacher*

Facilitating Conditions

All participants said that the indoor sessions were good practice for the outdoor session. Further, the practicing teachers believe that the manual[25] was useful since it helped better prepare for the final visualization session. For use of technology in general, the prospective teachers said that the schools, even if they have the technological equipment, they tend to prioritize factors other than technology. They said that the schools might have technological equipment, however, it is not used properly as the teachers do not know how.

> *Schools may have the technology […] but they don't know how it works […] it is expensive and they prioritize other things. // prospective teacher*

This was can be confirmed with a similar statement from one of the practicing teachers:

> *We have IWB's in almost all classrooms but not everyone can teach it. // practicing teacher*

The prospective teachers also point out that they themselves do not get enough education in using technology as teachers in schools and they would like to have more of that in their study program.

[25] A manual for the use of the visualization tool was given to all participants in advance for their own preparation

[There is] not enough education in the teacher education program on how to use technology in schools […][I] do not think it will be provided any either. // prospective teacher

The practicing teachers said technology such as computers and interactive whiteboards is available and the schools give education and training but the main issue is the lack of time. Both teachers believe there is not enough time given for adapting and updating their teaching: they have to put in time of their own outside of the working hours to learn how to bring technology into their teaching.

Computers are provided by the school but not working hours. I have to work in my own time. // practicing teacher

Experience/Habit

The prospective teachers participating were on their second year of studies and their teaching experience consisted of training only at schools within their study program. As a result of being prospective teachers their experience of using technology in an educational setting is limited and within their own studying program they had so far only been introduced to Photo Story[26] as part of one of their courses. The two practicing teachers were teaching in different primary schools and, when asked about their use of technology in their work, they said they used it to some extent, new directives were given that all student-parent meetings with the teachers must be documented on the computer and they are not supposed to use paper and pencil. Further, they had access to interactive whiteboards.

Voluntariness of Use

As mentioned in connection with social construct, one of their arguments for using technology is evolution and the changing times which require the use of technology. As the practicing teachers put it:

I don't think we can choose in the future.

Someday I must do it.

The older generation will at first say "I don't have any other choice, I have to."

What is important for the teachers in order to use the technology is that it should not take too long to prepare the work and it should also be easy to use. Further, one of the teachers says that they need to be comfortable with the technology and to replace what already works with something else requires that the new thing adds much more value and benefits. About replacing the whiteboard, or even the blackboard, to an interactive whiteboard, a teacher said that:

If I am going to replace my board with one of those it has to add weight, it must be so much more. // practicing teacher

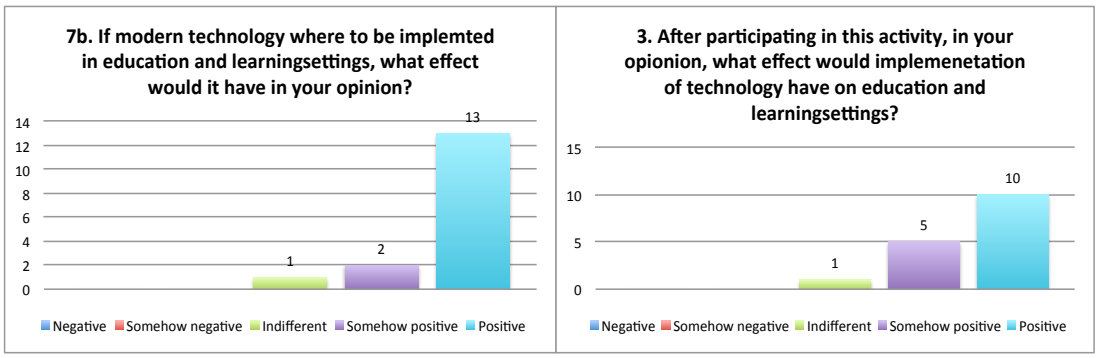
Even if both practicing teachers had the same perception about using technology in their teaching, one of them believes that the use of mobile and ubiquitous technologies is interesting, and is open to and believes that they could learn from the use of it.

Survey

Prior to and after the LETS GO teacher education trial was conducted, a survey was given to all participants. In total, 16 prospective teachers and the two practicing teachers participated. The overall results of the survey lie within the positive side of the Likert-scale

[26] Software for digital storytelling.

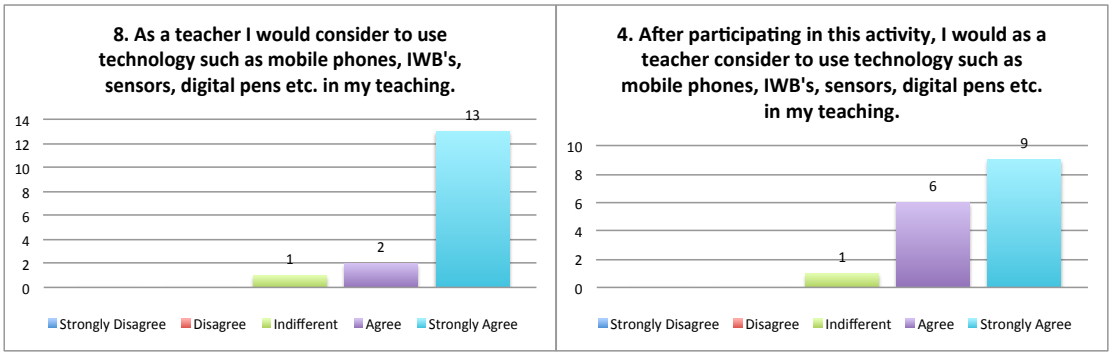
although, while the overall result of the survey was positive, the post-survey results were lower than the pre-survey ones. One of the questions, which can be categorized within the 'Performance Expectancy,' was their opinion on the effects of mobile and ubiquitous technologies in education and learning practices: 13 out of 16 prospective teachers answered positive and 2 somewhat positive while, in the post-survey, the outcome of the same question was 10 out of 16 were positive and 5 somewhat positive. This has can be seen in Figure 5.2:



pre-survey post-survey

Figure 5.2 Effects of technology on education and learning settings

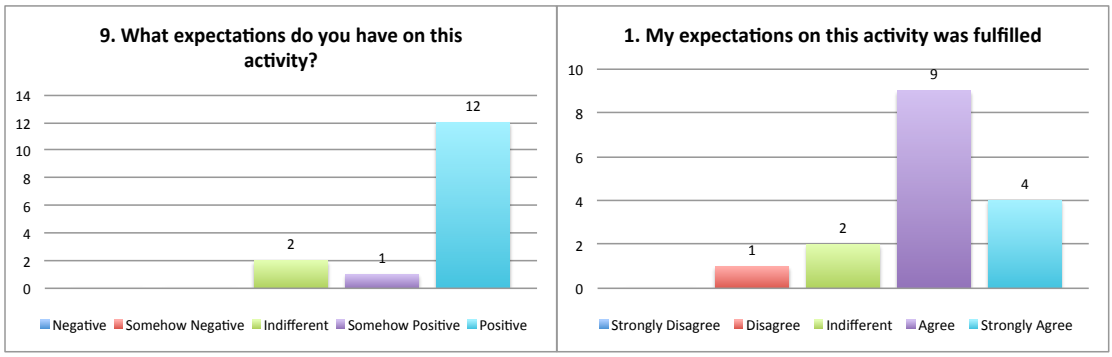
Further, in regard to Voluntariness of Use, the prospective teachers were asked if they would consider using technologies such as the mobile phone, interactive whiteboards, sensors, digital pens, etc. in their teaching (see Figure 5.3) and the result was once again 13 out of 16 Strongly agreeing with this statement on the pre-survey while on the post-survey the number decreased to 9 Strongly Agree and 6 Agree.



pre-survey post-survey

Figure 5.3 Considering using technology in teaching

Figure 5.4 illustrates that, despite the changes in the responses after the trial, the expectations of the prospective students were fulfilled, 9 out of 16 agreed and 4 strongly agreed while at the pre-survey 12 out of 16 had positive expectations.

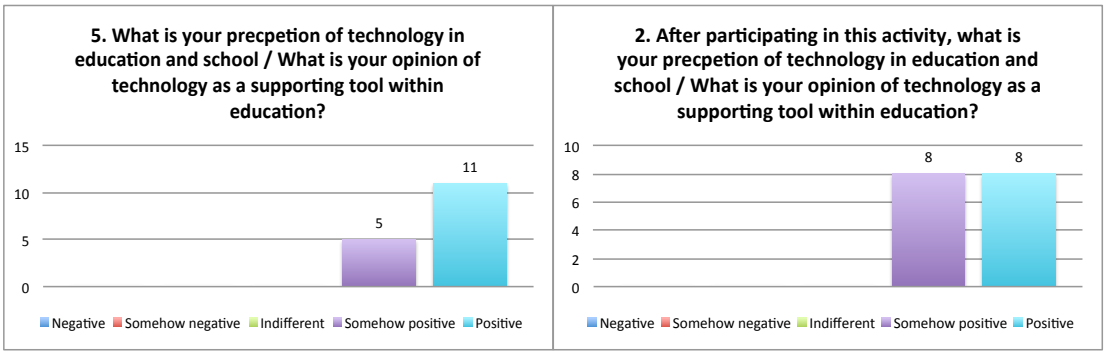


pre-survey post-survey

Figure 5.4 Trial expectations

As with Effort Expectancy, the data illustrated that 6 prospective teachers believe working with mobile and ubiquitous technology as with the LETS GO activity would be more time consuming than preforming the same task traditionally while 5 were indifferent and 2 disagreed and 2 more strongly disagreed.

14 participates believe technology should function as a supporting tool in education. Further, 10 agree and 5 strongly agree with this approach being a successful way in schools. As illustrated in Figure 5.5, in the pre-survey the number of prospective having a positive opinion of technology as a supporting tool within education was 11 out of 16 while after the trial the number decreased to 8.



pre-survey post-survey

Figure 5.5 Perception of technology as a supporting educational tool

In regard to their own education, the majority believe technology has not been used in an optimized way: 4 prospective students strongly disagree, 4 disagree and 4 are indifferent to the statement that technology has been used in an optimized way in their own education.

5.2.3 Collboard

During spring 2010 the Collboard project was conducted at a secondary school with two teachers participating. The project was a mathematics project conducted in a classroom setting, focusing on New Media Literacies and using interactive whiteboards and digital pens.

Performance Expectancy

One of the main issues mentioned by both teachers was the ability of all students to actively participate and contribute. They continue by mentioning increased collaboration,

interaction and discussion between not only the students themselves but also between the students and the teacher as

a way of fostering active learning, participation and collaboration.

one way of increasing interactivity among both teacher-student and student-student.

One teacher mentioned that, during this project, the students were forced to have a discussion on different methods and approaches to solve the task and this sort of discussion are very much to be desired, as students learn best through discussion. One of the teachers also explained this could enable the oral activity in the classroom, especially among students who are not too fond of speaking.

All students being able to contribute was mentioned by both of the teachers:

It is okay if one has not reached the final solution, but they can still contribute.

[It is] a good way for the students to feel that they have contributed.

A further issue mentioned by one teacher was the possibility of collaborating with other colleagues through use of mobile and ubiquitous technologies:

The system integrating with other systems would increase collaboration between teachers as well as students and contribute to shared learning.

Collboard was believed to foster active learning, participation and collaboration.

Effort Expectancy

Both teachers believed it was easy to use the technology, and to prepare a lesson with Collboard would not necessarily take longer to prepare than traditional lessons:

Just put the problem in the software and you are ready to go.

Ease of use could also been identified in the observations where both teachers were more in charge in the initial sessions but eased up eventually and by the end gave more control and space to the students. It was clear that both teachers were aware and comfortable using the Collboard software on the interactive whiteboard and guiding the students when needed. The main drawback already mentioned which influenced the effort construct was the large class size. One teacher was concerned about how it would be possible to activate all students if the class for instance consisted of 28 students in contrast to the six students per group during the trial. The other teacher was concerned about the time required to carry out the activity as designed for the Collboard projects which s/he believed was quite time consuming. Dividing the activity into two lessons could be a way to gain some time, concluded the teacher. One of the teachers said the use of the Collboard does necessarily not have to take longer than preparing a regular lesson:

It could take some time before getting used to the technical part and then one has to…or not really, finding tasks which needs discussion can occur in normal settings as well"

Facilitating Conditions

Proper training is considered by both teachers to be necessary in order for teachers to be comfortable with adopting technology in their teaching:

In order to be comfortable with the technology there is the need to be educated in it.

One of the teachers believed that, with the proper education, the users can be shown that working with the technology is simple and, therefore, most people would use it.

A further issue mentioned is the lack of time in each lesson which affects the use of the software rather than the number of students.

Experience/Habit

Both teachers participating in the Collboard trial have had some experience using technology, namely interactive whiteboards, in their teaching. The teachers mentioned that they have not used much of the interactivity function of the whiteboards, so the board has not been used for activating or interacting with students but, rather, as more advanced traditional whiteboards.

Voluntariness of Use

One teacher believed all ways of learning with technology to be very positive although there is a need to show that it is easy to use and to provide the right training. The other teacher says that

> *with the right training and showing that is it simple to use, most people would work with it.*

Other

An interesting factor mentioned by the one teacher not covered by any of the UTAUT constructs nor moderators is the "student factor." At one point during the interview the teacher said that there are other factors beside the technology that influence the use of the technology, especially in larger classes. S/he argued that the student groups themselves, again, especially in larger classes influence the use of the technology in educational settings. Student groups similar to the student group s/he had during the Collboard trial could work in bigger-scale classes while s/he was not sure this would be the case with different types of students:

> *With the math group I have right now, which has a good combination, it would work with 18-19 students. If we take the natural science group where it is a whole class[27] for example, I don't think this would work, maybe if there were another set of students [...] it is not about the technology, it is other factors that come to play.*

5.2.4 Summary and Conclusions of the Deductive Analysis

To analyze the teachers' perception and acceptance of using technology in their everyday teaching, constructs and moderators from the UTAUT and UTAUT 2 models have been used. The analysis model that has been used is illustrated in Figure 5.6.

[27] Full classes in Sweden usually consists of 22-28 students

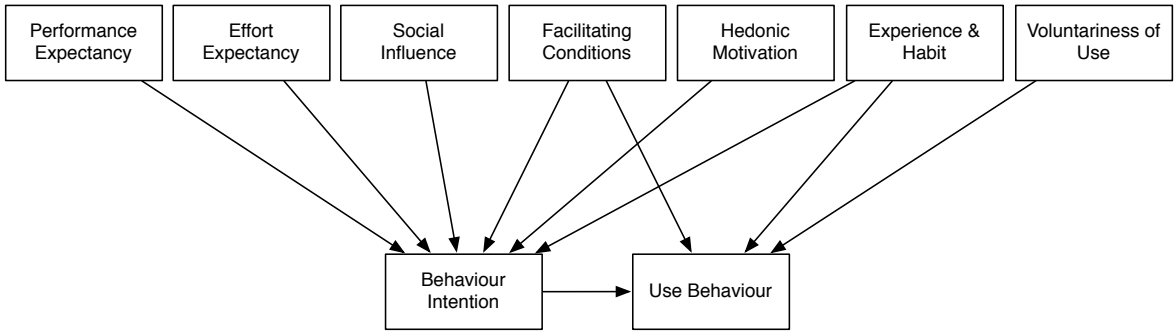


Figure 5.6 (Copy of Figure 4.3) The Unified Theory of Acceptance and Use of Technology Thematic Analysis (merged from Venkatesh et al., 2003; Venkatesh et al., 2012)

The teachers' perceptions and acceptance towards using technology across the three projects have been quite similar, although the LETS GO project had a slightly different attitude and that is most likely due to the participants performing the tasks and acting as the students rather than teachers conducting the class.

Experience and Habit, one of the constructs that directly influences use behavior, was quite thin in the empirical material and based on what the participant actually mentioned. Most of the teachers had some experience of use of mobile and ubiquitous technologies in their teaching but it was very limited. The prospective teachers were the participants most lacking experience of mobile and ubiquitous use since they did not use technology much in their own education. However they believed it is easier for them to grasp and relate to use of mobile and ubiquitous technologies as it is part of their everyday life. This indicates habit and experience, not in educational settings and teaching but in informal, everyday life.

The main factor for Performance Expectancy is the active-, participating- and collaborative learning of the students. The teachers in both GeM and Collboard said that the use of technology creates spaces for discussion and collaboration, which in terms of the Collboard teachers activates and involves the students. They were able to contribute and take part in their own learning. This was also mentioned differently by the practicing LETS GO teacher who believed that technology enhances learning regardless of different learning styles. Moreover, the factor of doing things practically and, for GeM and LETS GO, to be able to go outdoors and gain a different experience, was also considered gains in performance.

During this analysis it is possible to see that Effort Expectancy and Facilitating Conditions directly influence the Voluntariness of Use and, thereby, the teachers' acceptance of use of mobile and ubiquitous technologies in their teaching. Although some teachers found the technology to be difficult, the majority believed the technology to be easy to use and understand (Effort Expectancy) and, with proper education and training (Facilitating Conditions), the technology becomes easier to use and focus can switch from learning and adopting the technology to enhancing the students' learning. The ease of use, reliability, user-friendliness (Effort Expectancy), proper education and training (Facilitating Conditions) together with the change of societal requirements and demands (Social Influences) influence the teachers' willingness to use technology in their teaching at school. Within the GeM and Collboard projects the teachers mentioned that the willingness and actual use of the technology is dependent upon the technology being easy to use (Effort Expectancy), and trustworthy. As one of the GeM teachers mentioned, if the technology does not work for some students the teachers will not be willing to use it further and, even if there are a number of teachers who can overcome the problems, the use of technology will not be

common unless it is trustworthy so that the teachers can handle it easily and with confidence. The teachers from the teacher education trial of LETS GO brought a different viewpoint to the Voluntariness: they mentioned evolution and the pressure from society and that they actually need to see the benefit in order to give in and use the technology; also that they actually do not have a choice as this is the direction life is moving towards. The fact that these two teachers' perceptions and attitudes towards technology differs from the other teachers is clear, since neither of the teachers in GeM or Collboard explicitly mention having no other choice than using technology in the future It is not clear from the research context, and empirical material if this is because practicing teachers in LETS GO randomly participated in the trial as part of the course they were taking at the university, or that they belonged to the group of teachers who did not see technology as simple to apply as the other teachers did.

Beside evolution and society influencing the use of technology, as mentioned by the teachers in the LETS GO project, the students were influencing the teachers conviction on using technology in teaching. It was considered important to modernize the way education is conducted and to keep up with the interests of the students and to offer them an education they respond to and that stimulates them as well as being exciting for them.

The conclusion of this analysis is in regard to the UTAUT models as such. Within this analysis the models have not been used in their complete sense. This is due to the fact that these models are primarily used for quantitative analysis (Venkatesh et al., 2003) while the empirical material in this research mainly consists of qualitative data (see Chapter 3.3). The data from these three projects was not initially collected with the intention to analyze and discuss the acceptance of technology. Hence, the models have not covered all relevant issues in the empirical material and the empirical material has not been fitted to any of the models. As can be seen in the all projects (see Appendix H, Appendix I and Appendix J) the moderator Voluntariness of Use has been moved to the constructs (see Figure 4.3) and for the Collboard project an additional 'construct' named Other was added. Further, this analysis has not moved beyond the constructs and moderators to the Behavior Intentions and Use Behavior (see Figure 4.1 and Figure 4.2), this due to the lack of iteration within the model[28]. By identifying the different constructs and the moderator Voluntariness of Use within the different project the teachers' perceptions and acceptance of technology in educational setting has been explored and a number of factors, as presented above, has been identified for further analysis.

5.3 Bringing the Results Together

In both analyses there are clear patterns and indicators pointing at similar factors influencing the everyday novel use of mobile and ubiquitous technologies in teaching and learning practices. The rich picture below (see Figure 5.7) represents the situation based on the results of the two analyses combined.

[28] For further reflection and discussion of the UTAUT model see Chapter 7.1

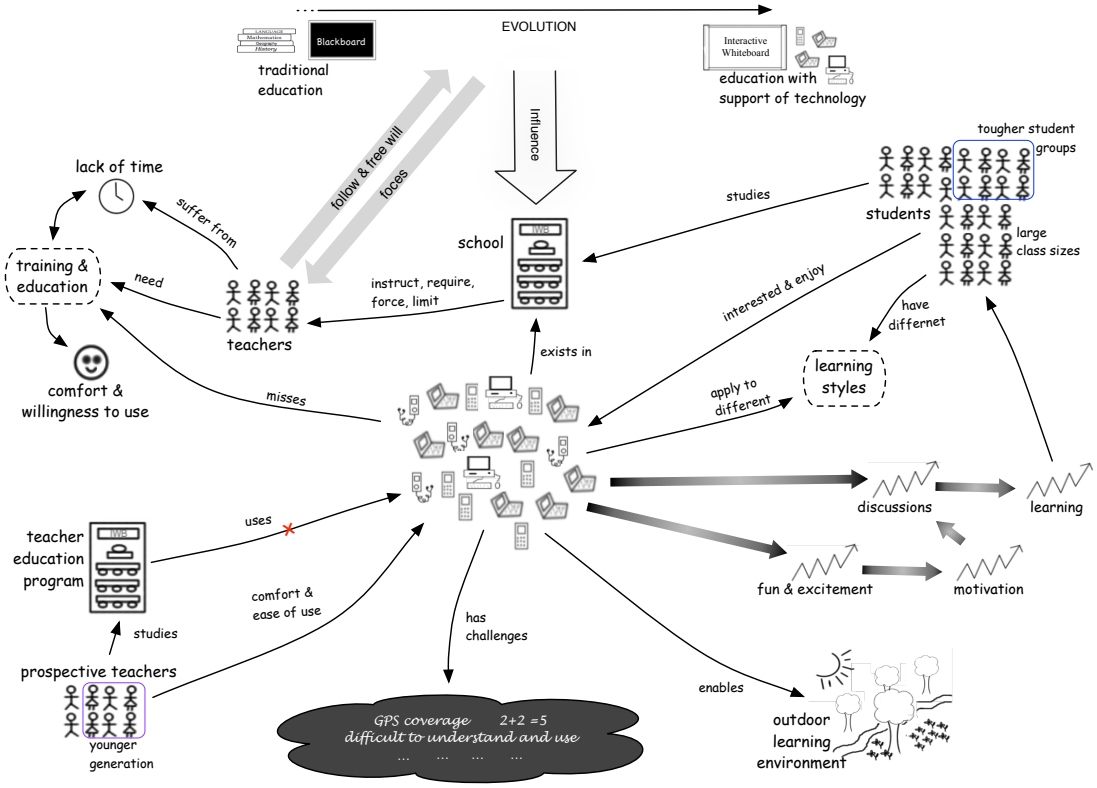


Figure 5.7 Empirically based problematic situation

The students are situated on the right of the rich picture. The students experienced the use of mobile and ubiquitous technologies as being fun and believed they learned more by using mobile and ubiquitous technologies. This was confirmed by the teachers, as well as acknowledging that mobile and ubiquitous technologies can be applied to the different learning styles and senses that the students have. This is in line with the Social Influence factor of UTAUT; it is clear that the students' attitude and experience affect the teachers' attitudes and willingness to use mobile and ubiquitous technologies in their teaching. The Social Influence in terms of the importance and pleasure of using mobile and ubiquitous technologies by the students could in an indirect way lead to Hedonic Motivation for the teachers in terms of perception towards use of technology. However, this could not be identified in any of the analyses and neither could other hedonic factors for the teachers. Some challenges the teachers mentioned with regard to the students was large class sizes that make it more difficult to actively engage the students, which would otherwise have been seen as one of the added values. One of the teachers also mentioned tougher student groups that, regardless of use of mobile and ubiquitous technologies, are challenging for teaching.

The middle and bottom right side of the picture illustrate the added value brought by mobile and ubiquitous technologies. Based on their experience, the students and teachers believe technology enabled having fun while collaboration, discussion and learning are enhanced. As illustrated in the image, having fun is believed to increase the students' motivation, which increases the discussions and is, therefore, believed by the teachers to be highly important. Further, the possibility to take learning into an outdoor environment is perceived as added value as it helps students to enhance their understanding by being more active and having more discussions.

The dark cloud at the bottom of the picture illustrates the challenges encountered by the teachers and the students with the use of mobile and ubiquitous technologies. The challenges

mainly consisted of inconsequent values by the devices, but also devices not working properly such as GPS coverage or digital pens losing quality due to some minor noise. There were also teachers and students who believed the devices to sometimes be a bit difficult to understand and use although, with some practice and getting used to the devices, they become more comfortable.

On the left of the picture are the teachers. As mentioned above, the teachers experienced both added value and challenges in the use of mobile and ubiquitous technologies. For the adoption of mobile and ubiquitous technologies, it could be found that the students and social aspects were important. Above the teachers, a timeline is shown, indicating society evolving towards greater use of technologies and, as mentioned by one of the teachers, teachers are being forced by society to adapt to the changes and to use mobile and ubiquitous technologies. There are also teachers who, through their own will and interest, choose to adopt and use mobile and ubiquitous technologies. The teachers believed the benefits of changing what they have affect their voluntariness of use. Further, as illustrated to the left of the teachers, training and education was considered highly important. The Facilitating conditions in combination with Effort Expectancy, that implies the technology is easy and comfortable to use, was mentioned by most teachers and was considered important. Time was an additional issue the teachers mentioned, mainly as a challenge since they do not always have the time to adapt to the technologies but also the limited lessons time which not always makes it possible to conduct teaching in similar way as the projects.

The prospective teachers are located at the bottom left of the picture. The prospective teachers in general had a positive attitude towards the use of mobile and ubiquitous technologies in school education. They could see themselves using mobile and ubiquitous technologies as part of their teaching on finishing their education; despite this, their perceptions about the mobile and ubiquitous technology decreased after participating in the trial. However, the prospective teachers believed it being important be in line with what children are interested in, in order to get them interested and involved. The prospective teachers also mentioned that they do not use mobile and ubiquitous technologies in novel ways within their own education and, even if they wished they could have more training, they doubted it would be provided to them.

CHAPTER 6

Holistic Analysis and Discussion of Findings

This chapter presents a holistic analysis and discussion based on the results obtained from the conducted thematic analyses in Chapter 5 as well as the area of concern in Chapter 2, and documents from the Swedish Government and National agencies describing the use of mobile and ubiquitous technologies in Swedish schools, in Chapter 3; see Figure 6.1.

The empirical analyses in Chapter 5 focused on the students', teachers' and prospective teachers' experiences of using mobile and ubiquitous technologies, and on teachers' perceptions and attitudes about using mobile and ubiquitous technologies, providing some insight on what aspects influences the novel use of mobile and ubiquitous technologies, while Chapter 2 has provided insight from a theoretical and research.

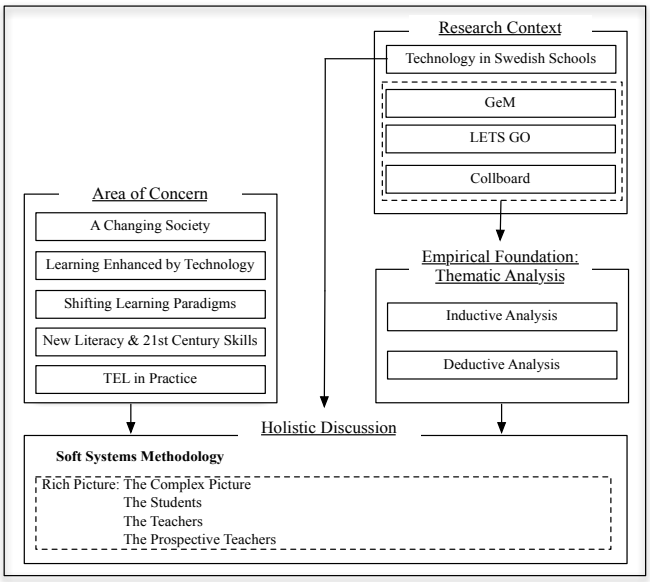


Figure 6.1 Holistic Analysis

By applying Rich Pictures of Soft Systems Methodology, a holistic analysis and discussion can be conducted, including a wider range of aspects and understandings based on the different actors, their worldviews and the relation between them.

The next section will present the complex picture illustrating the problematic situation as a whole, illustrating the different entities, actors, roles, and relationships. Thereafter, a more detailed discussion will be presented based on the students', teachers' and the prospective teachers' worldview, illustrating and discussing further aspects impacting the novel use of mobile and ubiquitous technologies in school education.

6.1 The Complex Picture

By applying Soft Systems Methodologies, and Rich Pictures, the different entities, actors, roles[29], relationships, and viewpoints have been illustrated and recognized. Figure 6.2 illustrates this complex situation. Initially this section will describe the different parts of the rich picture, in subsections, and then explain the notation of the picture. Thereafter, the discussion of the different parts and the picture as whole will be done in relation to the aim of this study.

As mentioned throughout this thesis, but mainly in the second chapter, the evolution of society is influencing all aspects of our lives, and we are moving towards a society highly influenced by mobile and ubiquitous technologies. This has been illustrated at the top of the image as a timeline with arrows pointing towards the different parts of the picture. Below the timeline, at the left, the various features of mobile and ubiquitous technologies have been illustrated, where the soft clouds represent positive features while explosive clouds illustrate the challenges. At the right side of these features, the mobile and ubiquitous technology is represented. Further to the right, the top right side of the picture, the students are represented. Within the student cluster, two groups have been represented by navy blue dashed lines illustrating students groups that are tougher to handle or have special needs and another group that are afraid or uncomfortable with the use of mobile and ubiquitous technologies. In the center of the rich picture, below the mobile and ubiquitous technologies, slightly to the right, the teachers are represented. To the left of the teachers, the results of the inductive analysis – increased discussions, active participation, collaboration and enhanced learning – are illustrated and, next to that the outdoor learning setting, illustrated as nature. In Chapter 2, the need for new skills and literacies was identified. The new skills, literacies and subjects matters are illustrated below the outdoor learning environment. On the lower left-hand side, the working environment is illustrated by organizations, companies and service providers connected to the new skills and literacies they may require from the future generations. To the right side of the teachers, a classroom is represented and, further to the right, is the School Act 2010:800 and the national curriculum, Lgr11[30]. Below the school act and the curriculum, grouped with a dashed gray line, technology enhanced strategies and models are illustrated. These documents have been created and provided by the Swedish Government, National Agency of Education as presented in Chapter 3.1. Together with the city councils and municipalities, responsible for the implementation and follow-up of these documents, and the European Commission, the provider of the digital agenda for Europe,

[29] Entities are referred to as distinctive 'things' existing independently. Actors are referred to as those who participate or perform an action or process. Roles are referred to as functions and actions assumed by a person

[30] The 2011 national curriculum for school, preschool and leisure-time. See Chapter 3.1.

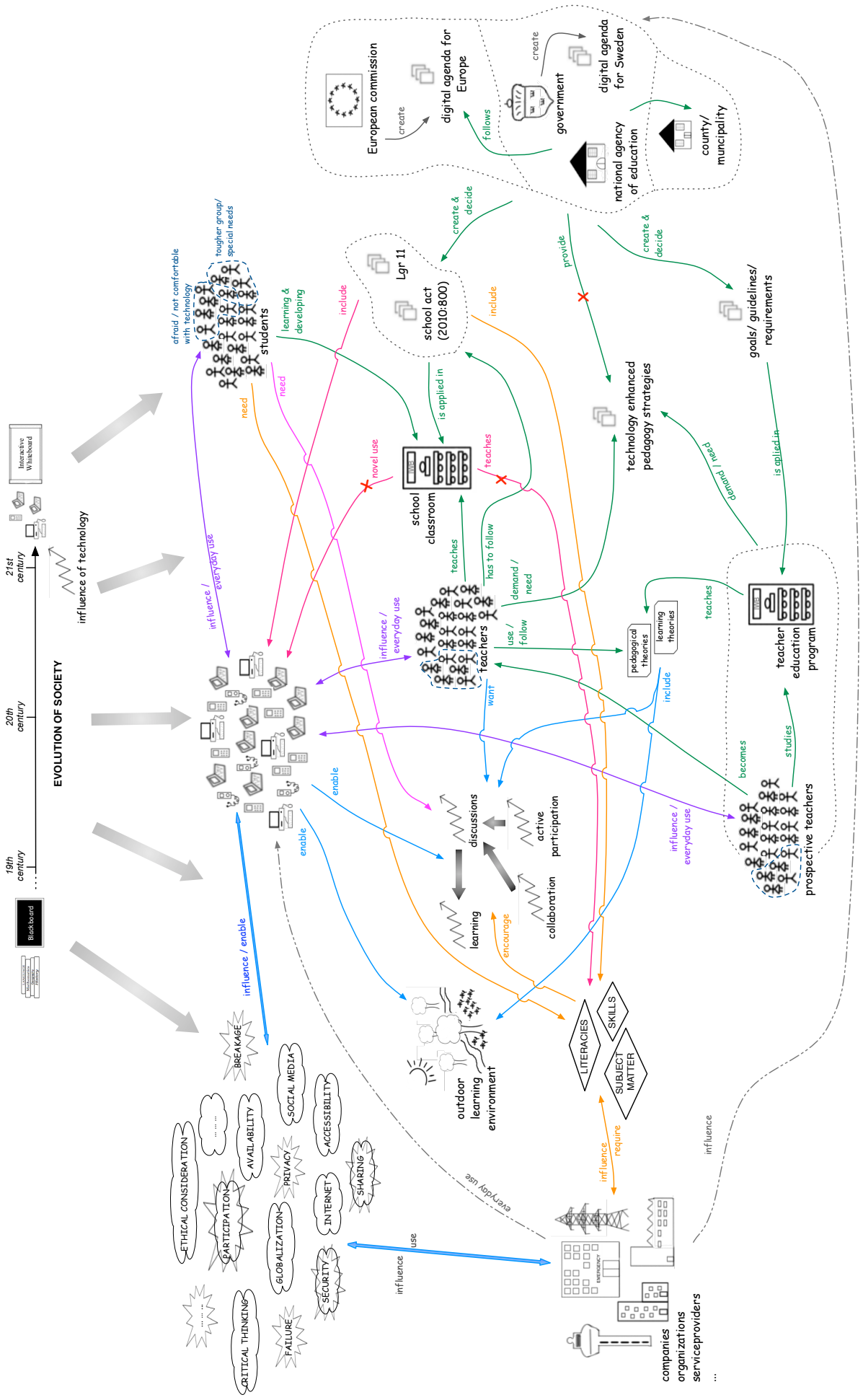


Figure 6.2 The Complex Picture

the authorities have been grouped with a gray dashed line. The authorities are represeted on the right side of the School Act, Lgr11 and the Technology Enhanced strategies. At the bottom of the picture, the teacher education program with the prospective teachers is shown. The goals, guidelines and requirements for higher education are shown between the teacher education program and the authority group.

The relations between the different actors and entities have been illustrated with different colored arrows: the green arrows illustrate the relation within the formal aspect of educational practices; pink illustrates the relation of inclusion and use of mobile and ubiquitous technologies in relation to education. New literacies and skills have been illustrated with orange arrows while light blue shows the possibilities enabled by mobile and ubiquitous technologies. The rest of the arrows indicate the informal relations outside educational practices, although still being important for the overall situation. Purple arrows indicate the use of mobile and ubiquitous technology in everyday life but also the influence of mobile and ubiquitous technologies in the everyday life of students, teachers and prospective teachers. The gray dashed arrows illustrate the impact of working life on mobile and ubiquitous technologies as well as on the authorities. From the working environments and mobile and ubiquitous technologies, thicker darker blue arrows illustrate the influence the possibilities and challenges of mobile technologies but also the usage and enablement.

As there is no logical flow on how the rich picture should be interpreted, this section will, part by part, describe and discuss the complex rich picture and how each part, relation, entity and actor is influenced by and influences its surrounding. The same will follow for each subsection and focuses on specific worldviews of the students, teachers and prospective teachers.

Society is evolving towards a more knowledge- and technology-driven society and this is mentioned by scholars (Bradley, 2006a; 2006b; Johnson et al., 2011) as well as by teachers. The evolution of society is illustrated at the top of the picture where society is moving from traditional books and the chalked blackboards to a society that is highly influenced by technology. The use of mobile phones, computer desktops, and laptops are becoming more common, and Interactive Whiteboards have mostly replaced the traditional blackboard (Skolverket, 2013). Evolution of society is the most powerful and influential factor. It influences all instances of society, the development of technology, the way organizations and working life is conducted, organized and carried out as well as individuals such as the teachers, the students and the prospective teachers. The European Commission, the Swedish Government, The National Agency of Education, Municipalities and local schools are actors in the society and influenced directly and indirectly via the working environment, the technological development but also individual people.

The Formal Learning Environment

In the right side of the picture (see Figure 6.2.1 for close-up) the formal part is illustrated. The Swedish Government and the National Agency of Education has the formal power within the formal educational setting following the European Commission and the digital agenda for Europe. The School Act and Lgr11 is developed and provided by the Swedish Government and the National Agency of Education following the Digital Agenda for Sweden. The documents include use of mobile and ubiquitous technologies as well as mentioning new skills and literacies without explicitly using scientific concepts and definitions of them. Although, as mentioned by for instance Gärdenfors (2010), the Swedish School Inspectorate (Skolverket 2011; Skolverket, 2012) and the National Agency of Education (Thullberg & Szekley, 2009), the governmental level fails to provide strategies

and/or guidelines and pedagogical models for how the new requirements for use of mobile and ubiquitous technologies should be implemented, adopted and used in everyday teaching and learning practices. Further, the role of municipalities, as governing school, and school managers who can implement and adopt the School Act 2010:800 and Lgr11 in their own way and with their own interpretations, resulting in different levels of mobile and ubiquitous equipment and its use. Although schools might, and to some extent have to, invest in various mobile and ubiquitous technologies, the analysis shows that they are used to a limited extent. This outcome is accordance with realted research. For incance, Gärdenfors (2010) argues that schools equip themselves with mobile and ubiquitous technologies in order to cover for the lack of new pedagogical models. This is in line with the statement of the OECD (2010), which claims that the educational systems believe that the equipment will sooner or later be adopted and used by the teachers. But it is not as simple as that: as shown in the inductive and deductive analysis, the prospective teachers in the LETS GO project explained that schools might have mobile and ubiquitous technologies but they do not know how to use them. The limited uses of these technologies was also identified among the practicing teachers involved in the studies. The technology exists although what is lacking is the knowledge and time, as well as for some to see the opportunities and added value brought by mobile and ubiquitous technologies in teaching and learning practices.

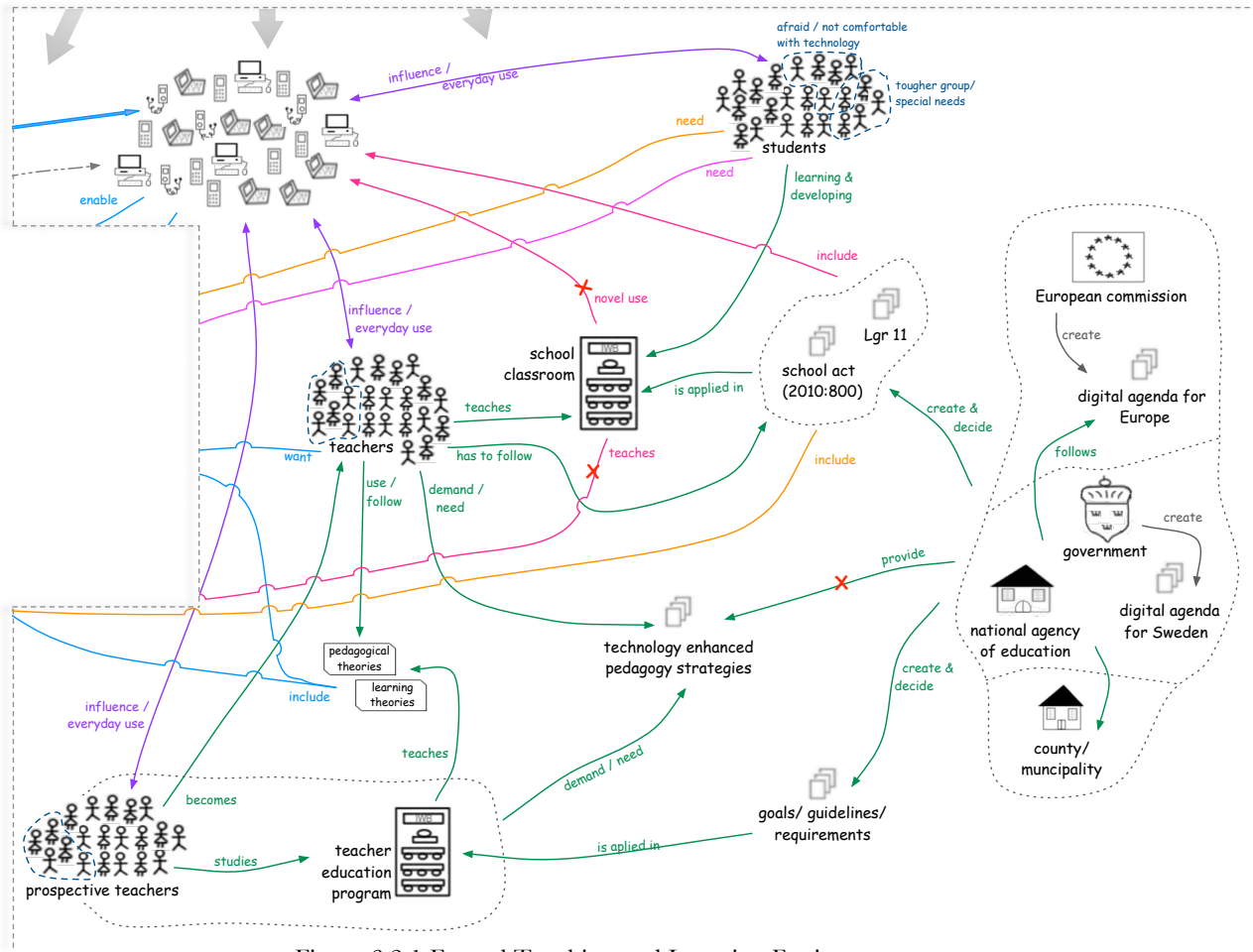


Figure 6.2.1 Formal Teaching and Learning Environment

Within the decision hierarchy, the teachers are in the bottom but, at the same time, they are the main actors in this complex situation as they are those who are supposed to use the mobile and ubiquitous technologies in novel ways as part of their everyday teaching. The teachers follow certain pedagogical models and have different approaches to teaching but will have to adjust their teaching to follow the School Act 2010:800 and Lgr11. As shown in both inductive and deductive analyses, the teachers also need to consider that students are not a homognius group. Hence their needs vary as well as preferred learing styles.

At the bottom of the rich picture, Figure 6.2.1, the prospective teachers are represented. Even though they do not have any formal influence or power, the prospective teachers are those who will one day be teaching in schools. The teacher education programs need to follow policies, requirements and guidelines including pedagogical theories and learning theories the school teachers follow and also the current School Act and national curriculums. What was identified in both related research (CMA, 2009; Thullberg & Szekley, 2009; OECD, 2010) but also in the empirical analyses, is that the teacher education program is lacking use and pedagogics concerning mobile and ubiquitous technologies. This is mentioned by the prospective teachers participating in the LETS GO project as well as reports from the Swedish National Agency (Tullberg & Szekley, 2009), the School Inspectorate (Skolverket, 2011) and other scholars and authors (CMA, 2009; OECD, 2010). One concerning issue is the prospective teachers' belief that they within their teacher program will not get enough education in the use of mobile and ubiquitous technologies in teaching and learning practices, despite their interest.

At the right top of Figure 6.2.1, are the second main actors, the students. The students are those who are the main beneficiaries as they are those who will be affected the most in the complex situation represented in the rich picture. Based on the empirical analysis the students have been distinguished in two different groups: students that are afraid of and/or uncomfortable with use of mobile and ubiquitous technologies and students who have special needs or are in some way more demanding and tougher. These groups of students have been identified in for instance the Collboard and LETS GO project and do affect the teachers in the class using mobile and ubiquitous technologies. Although most of the students enjoy the use of mobile and ubiquitous technologies, as it has become part of their everyday life. This is acknowledged by teachers who participated in the projects, the scholars and researchers as well as by the students. Despite the great influence of mobile and ubiquitous technologies in the students' everyday lives, the related research (Jenkins, 2009; Scardamalia et al., 2010, Lankshear & Knobel, 2011; Griffin et al., 2012a) indicates that they are in need of new knowledge, literacies and skills in order to be able to meet the future. This should, as argued by e.g. Jenkins (2009), be provided by their school and the teachers as well as by parents and in afterschool programs. When learning, students use different senses and have different learning styles and, according to teachers, using different media such as mobile and ubiquitous technologies is positive and is in addition perceived by the students as more exciting and fun. However, although the students are receivers and beneficiaries, they also have an informal power and influencing power in bringing mobile and ubiquitous technologies into the school and the classrooms. This is done by bringing in devices but also by bringing informal skills and knowledge to the classrooms to share with classmates and they influence one another, the teachers and the learning environment as a whole. The students influence and affect the teachers in a direct way in terms of social influences as seen in the deductive thematic analysis.

Opportunities and Challenges

In the center and upper left side of Figure 6.2 are the opportunities and challenges of mobile and ubiquitous technologies and Figure 6.2.2 presents a close up of that part of the complex picture. The thematic analyses as well as related research (Naismith et al., 2004; Pachler et al., 2010) demonstrated how mobile and ubiquitous technologies have the ability to break the classroom walls and bring in the informal surroundings to the classrooms. In addition, these technologies facilitate taking the learning and teaching outside the classroom walls. Learning can be more real and situated and students can gain a different understanding of what they learn and it does not become, as Kay (1972) argued, non-fruitful for years. Taking LETS GO as an example, the students were able to go to nature not only to take samples to bring back to class but also to do the measurements and make a more complete data collection which, later in the classroom with the visualization on the computer, could be discussed. With use of mobile and ubiquitous technologies to support and enhance teaching and learning, it is possible to create spaces and environments for collaboration and discussion on a different level and extent is what the teachers aim for and wish to achieve and, they argue, will enhance the learning of the students. This was identified in the deductive analysis within the performance expectancy construct and in the inductive analysis as advantages. Several students argued for being able to discuss and collaborate with one another in a way that made them all understand the task and learn in a positive way from each other. Thus the theme collaboration and discussion includes enhanced sharing of knowledge, understanding and learning. These results are illustrated by the increasing arrows in the middle bottom part of Figure 6.2.2.

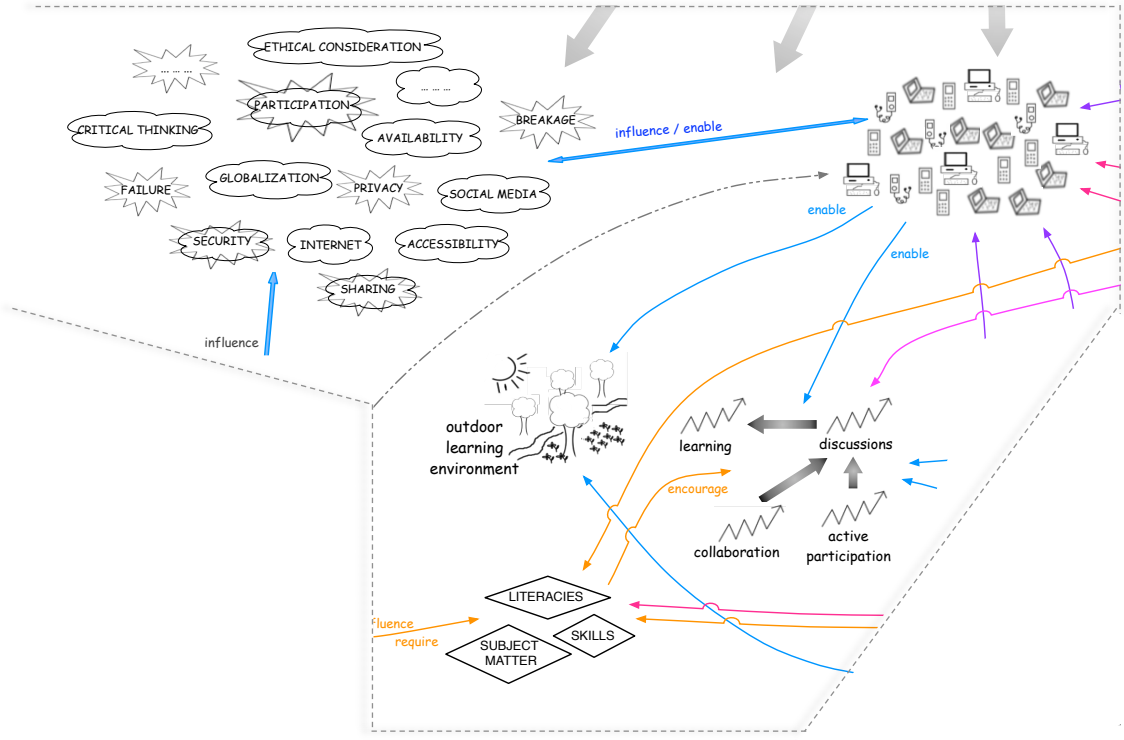


Figure 6.2.2 Opportunities and Challenges

Previous analysis shows both opportunities and challenges with mobile and ubiquitous technology. In the obove the opportunities are discussed and next the challnges will be put forward. Beside performance, perception, voluntariness, effort and comfort in use by teachers and students, the technology and its applications itself can be a challenge. The GPS was identified as a challenge due to bad connectivety. Students in the LETS GO project tried to get better access by standing on a stone to get a bit higher would help them get a more accurate position. For Collboard, the sensitivity of the digital pens were identified, as an example, were the digital pens not always registering what was written on the paper, making the students complement what they wrote later on the interactive whiteboard. These challenges were not conceived as bigger problems in the case of the projects but rather an inconvenience that can, if extended and reoccurring, create greater frustration and a distance from the use of mobile and ubiquitous technologies. Further challenges not concerned with the user or the technology per se are the opportunities enabled by mobile and ubiquitous technologies. These have, in the rich picture, Figure 6.2.2, been illustrated with symbolic explosions and consist of, among other things, the 'sharing' that is part of the participatory, user-generated data culture (Jenkins, 2009; Lankshear & Knobel, 2011). People are able, through the existence of mobile and ubiquitous technologies, to share knowledge and experiences as well as too-personal details, which can create risks and exposure of themselves and their private lives. As argued by Bradley (2010), the identity, self-perception, creativity, and social competence are features which can be strengthened or weakened by technology and this is something the teachers and formal education, together with the new skills and literacies, need to educate the future generation. The young generation of today has, to a considerable extent, knowledge and skills in the use of mobile and ubiquitous technologies but they are not always aware of the risks and challenges, and do not have the complete skills and knowledge required by society outside the home and school. This needs to be given to them within formal education.

The Surrounding Society

Mobile and ubiquitous technologies enable wider possibilities for informal learning as well as for formal learning (Pachler, 2010; Milrad et al., 2013), and part of the complexity to highlight, is for the schools and the teachers to balance these and enable them to benefit from one another. The informal learning of the students can with use of mobile and ubiquitous technologies be embraced and enhanced. Milrad et al. (2013) argue for seamless learning where learning can be achieved across settings and across devices and platforms. The students in that way can relate what they learn in school to what happens to their everyday life, and vice versa, and once again make learning more reality-based and situated.

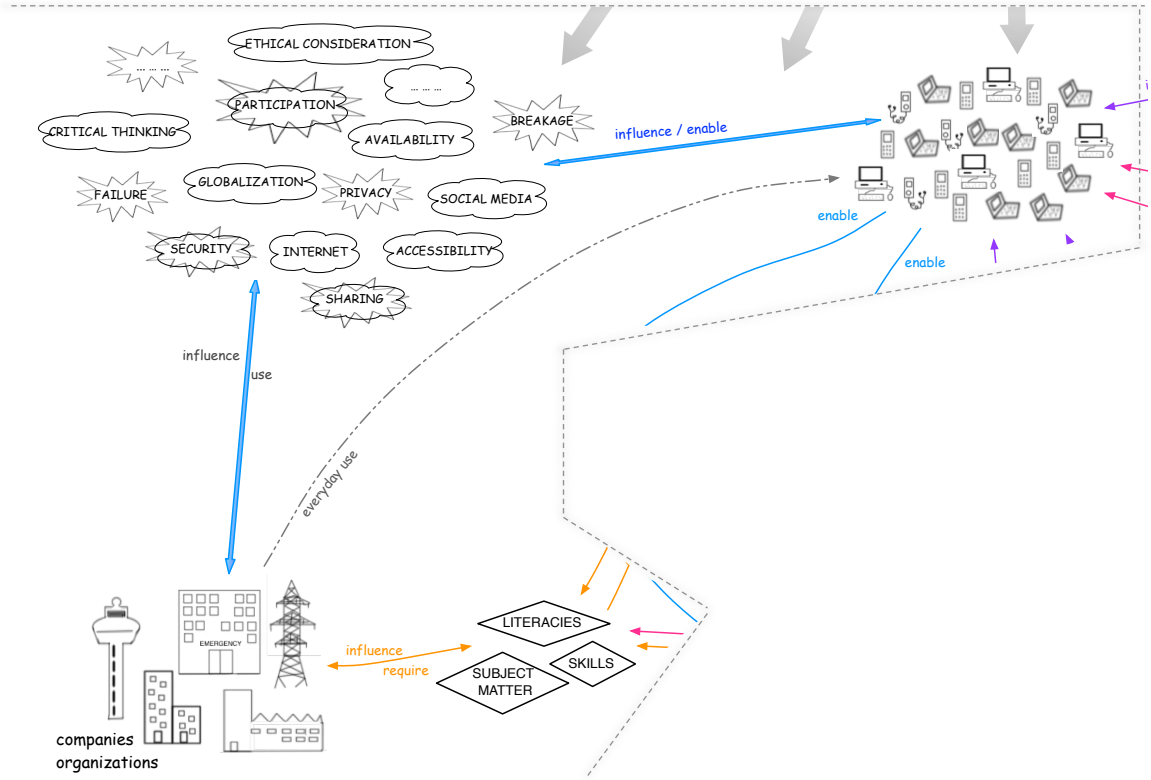


Figure 6.2.3 Entities in Surrounding Society

The left side of the compelx rich picture (see Figure 6.2), illustrate the working environment and the role of organizations, companies, service providers and other entities in the working environment. From the related research (Bradley, 2010; Griffin et al., 2012b) it can be concluded that mobile and ubiquitous technologies affect and change how working life is conducted and to some extent what kind of work is conducted. As argued by Griffin (2012b), the way we conduct work today has altered along with the tasks and the tools we use for living and working. On the other hand, the working environment has demands and requirements about what type of mobile and ubiquitous technologies they need in order to be able to conduct their work. These aspects together with the changes of society affect what kinds of skills, and literacies are needed in the working environment. This is very much argued by scholars while the teachers participating in the projects within this study did not mention the skills and literacies but rather learning as a whole.

Technology and knowledge are two of the greatest driving factors in society and thus there is the demand, the wish and the aim to use mobile and ubiquitous technologies in everyday educational practices in order to prepare the younger generation for their adult lives. As illustrated, described and discussed above, this is a complex, problematic situation. The following sections will therefore illustrate this from the students', the teachers' and the prospective teachers' perspective and, in further detail, discuss the different aspects and factors influencing the novel use of mobile and ubiquitous technologies in everyday teaching and learning practices.

6.1.1 The Students

The students of today are living in a society that is highly influenced by various mobile and ubiquitous technologies. Teachers that participated in this study's projects agree and argue that it is important to meet the students in their everyday life and prepare them for adult life in society and working environments (see also Jenkins, 2009; Scardamalia et al., 2010, Lankshear & Knobel, 2011; Griffin et al., 2012a).

Figure 6.3 represents the students' perspective, consisting of a formal learning environment marked with a green cloud and an informal learning environment marked with a blue cloud. The informal learning environment consists of the life, environments, situations, and people outside school. It also includes the formal learning environment. Within life outside school, parents and siblings influence the students as they live together and share experiences and knowledge gained during their own personal life on a daily basis. Without going deeply into the worldview of the people within the informal environment of the students, it is clear to see that parents are influenced by their working lives, bringing in their professional and public lives into their private life and home environment (Bradley, 2010). Similar patterns and influencing aspects can be seen for siblings as well as other friends, family and relatives bringing in and influencing students with their experiences, perception, and viewpoints from their education and working lives. Further, the changes of society influence people in the informal environment as well as mobile and ubiquitous technologies and all the possibilities and challenges it enables.

Today, mobile and ubiquitous technologies have become an essential part of the younger generation's everyday life, where social media, online information searching, participation and various types of sharing is done effortlessly and naturally. The Internet, with all its possibilities, is illustrated on the left of Figure 6.3 together with other aspects of mobile and ubiquitous technologies. Since mobile and ubiquitous technologies make up such a large part of the young generation's everyday life and constitute part of their knowledge, it is obvious that mobile and ubiquitous technologies will be found in the schools and classrooms. This brings positive and negative effects to the teaching and learning aspect as the students share experience, knowledge, etc. with one another while the teachers have to maintain the students' interest in what they are learning and doing in the classroom.

Within this study, in a formal setting, three groups of students, beside the general students that do not have any particular attitude towards mobile and ubiquitous technologies, have been identified mainly thought the thematic analyses: (1) students who are not comfortable with the mobile and ubiquitous technology either because they do not enjoy using it, do not like mobile and ubiquitous technologies overall or for other reasons. These students are generally more cautious about the use of the mobile and ubiquitous technologies and need more training and practice with the technology to become more confident with their use Students with greater insecurity were observed mainly in the LETS GO project, where they were extra careful when dealing with the sensors in the initial sessions. In Collboard, similar students were identified in the initial sessions being careful at the Interactive Whiteboard while, in the later sessions, they preferred to do things themselves and said they knew how to handle the whiteboard pen. The second group of students, (2), comprises the tougher students but also the students with special needs and in need of more attention. As mentioned in the project 'Learning to write without a pen' (see Chapter 2.4.1), there are technologies developed for students with special needs. In the case of the presented project, the computer, sounding keyboard and sound synthesizers were used for regular teaching. The students needing extra support and help need to be considered and addressed

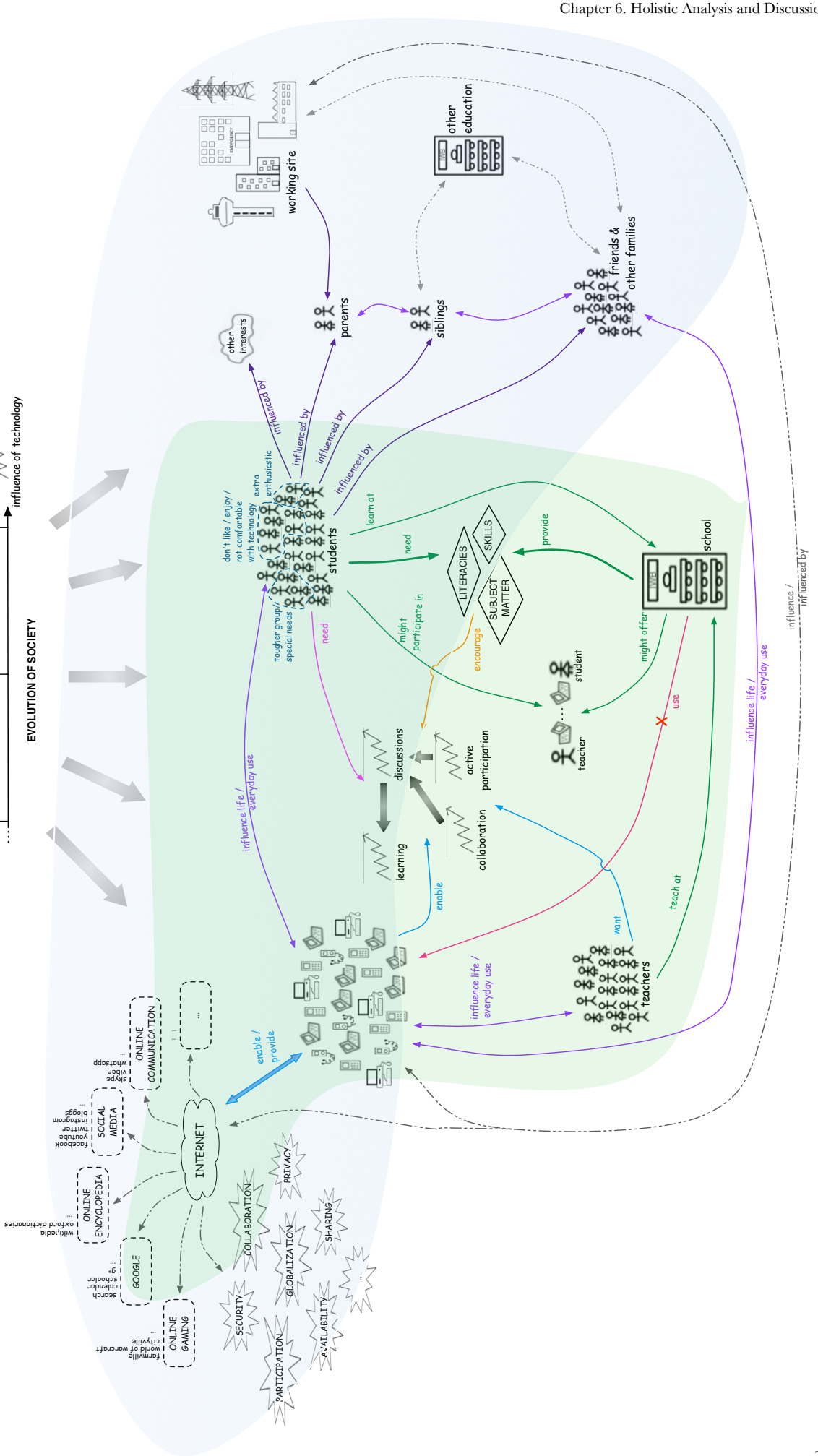


Figure 6.3 The Students Picture

in different ways when dealing with novel use of mobile and ubiquitous technologies so they can also participate and be active in their own learning. As for the tougher student groups, this was mentioned by one of the Collboard teachers, claiming that some students regardless of use of mobile and ubiquitous technologies are tougher to handle. The final distinguished group, (3), is the extra-enthusiastic students. These students have a high interest, curiosity and perhaps even knowledge about the use of mobile and ubiquitous technologies. Even if these students can be very driven and ambitious in their learning with the use of mobile and ubiquitous technologies, the teachers need to keep them under more supervision so that they share and collaborate with their peers but also not to do things other than they are asked. This was seen in both the Collboard and LETS GO project. Students in the Collboard project would like to keep the whiteboard pen and show classmates at the Interactive Whiteboard how to use them even if that particular student already knew how to. In LETS GO similar issues could be seen in that some students were in charge of the mobile phone, or students surfing the Internet at the final discussion session, and, of course, playing with the mobile phones.

In the middle of the rich picture, the experiences but also the need of the students is illustrated as increasing arrows. The analysis shows that the increased collaboration, discussion, motivation, and learning is experienced as opportunities and added values by the students and also the teachers. The importance of students being active has been highlighted by many prominent scholars such as Piaget, Vygotsky, Papert, Kay, etc. Mobile and ubiquitous technologies, when used in novel ways, can create space for more collaboration, and discussion and is something that is considered fun by the students, which, as Kay (1972) argues, creates higher willingness to put more effort in what is being done. The students themselves also enjoy using mobile and ubiquitous technologies when, for instance, learning mathematics, which has comprised two of the projects within this study. The students believed that by using mobile and ubiquitous technologies in the projects they were able to discuss with other classmates and teachers in a different way. They were exited and believed it was fun, which once again is in line with Kay's (1972) argument that children are creative and need to explore and that learning needs to be enjoyable.

The skills and literacies were identified, in the inductive anlaysis, as something the students can achive with more disucsstion, participation and collaboration enabled by mobile and ubiquitous technologies. These are illustrated to the right of the opportunities. The students can gain these skills and literacies on their own in their everyday life, as argued by Jenkins (2009), although as Jenkins continues, together with several other scholars such as Lankshear and Knobel (2007), and Pachler et al. (2010), it needs to be complemented in the formal education.

Mobile and ubiquitous technologies exist in schools. However, they are most often used in limited ways and with students not given the opportunity to actively participate and use the technology interactively. Though, there are schools and individual teachers who encourage and use mobile and ubiquitous technologies in novel ways, involving the students actively and giving them opportunities to gain skills and literacies they need for the future.

6.1.2 The Teachers

The teachers are the core actors within the problematic situation as they are the ones who have power and greater influence over adopting the novel use of mobile and ubiquitous technologies. Based on related research, policies and governmental documents and the empirical analysis it can be concluded that: the teachers are held back, limited, required and

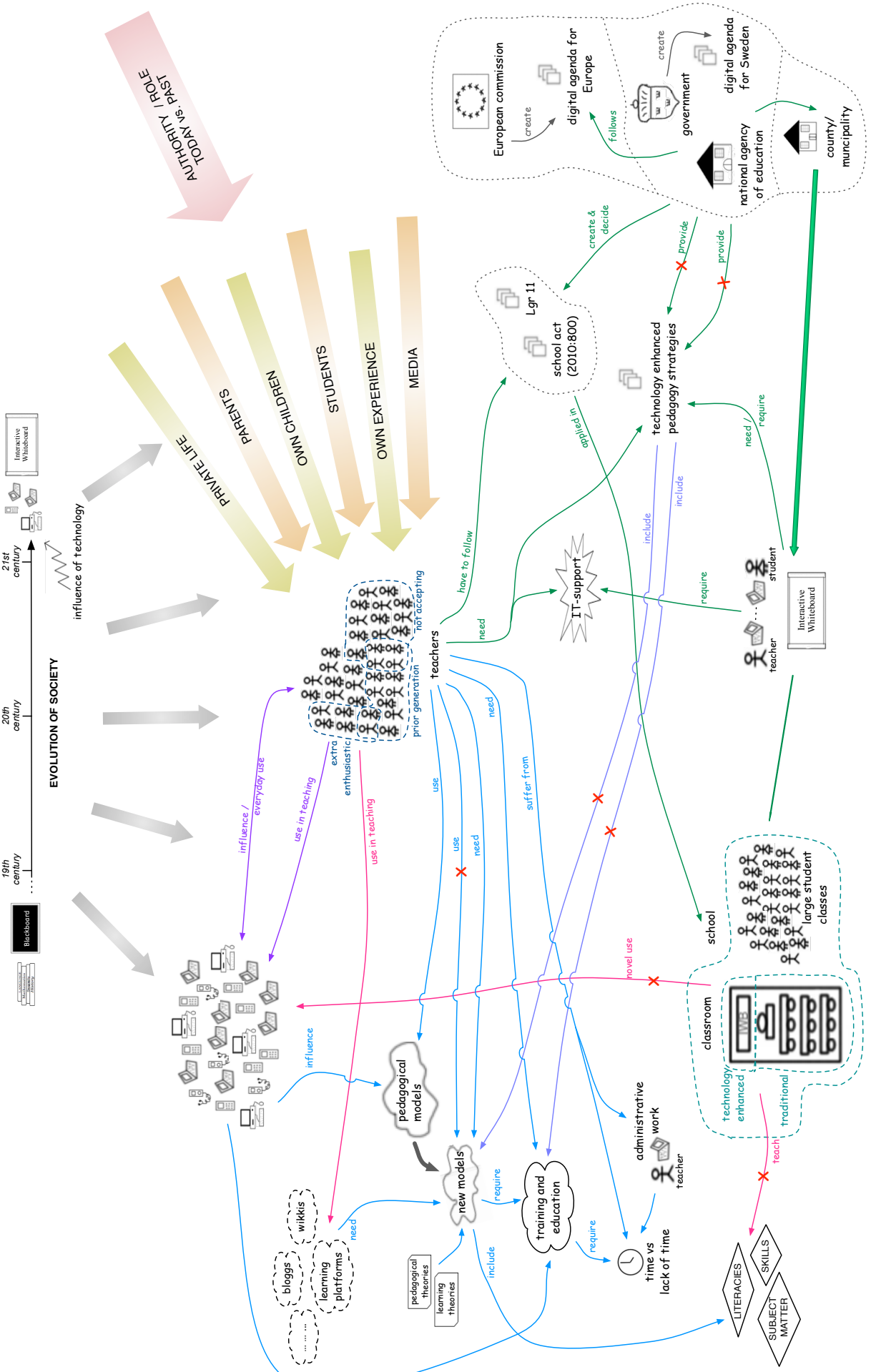


Figure 6.4 The Teachers Picture

in different ways pushed when it comes to using mobile and ubiquitous technologies in novel ways in their teaching by policies and regulations, as well as the existence and/or lack of equipment, and facilitating conditions.

The perspective of the teachers is represented in Figure 6.4, where four groups of teachers have been identified through both the inductive and the deductive analysis: (1) the prior generation of teachers, also included in one of the other groups. These have usually been teachers for several years and have experience and tacit knowledge in regard to teaching, learning about students and the educational system as such. The second group (2) consists of the enthusiastic teachers who have a genuine interest in the use of mobile and ubiquitous technologies for teaching and learning purposes. The enthusiastic teachers can either be younger teachers with an overall interest in mobile and ubiquitous technologies or prior generation teachers who are confident in their roles as teachers and have much knowledge and experience to lean on. These enthusiastic teachers adopt and integrate the novel use of mobile and ubiquitous technologies in their teaching and as part of their students' learning. This is done by teachers themselves without any requirements or demand and education or training in the novel use of mobile and ubiquitous technologies in educational practices. The non-accepting teachers (3) would rather keep to traditional teaching and learning but are forced by the change in society and governmental guidelines, requirements and demands from the school to adapt to the changes. The reasons for not adopting and embracing novel use of mobile and ubiquitous technologies vary. The younger generation of teachers wishes to be an integrated part of the specific school and their colleagues. If the school environment is not open or happily embracing novel use of mobile and ubiquitous technologies, the new teachers might not challenge the existing environment and do differently than is done at the specific school and will follow the trends and changes as they come. Lack of teaching experience can also be an issue for younger teachers as well as not having training in teaching with mobile and ubiquitous technologies from their teacher education program. From the deductive thematic analysis, the construct of voluntariness of use it can be concluded that some prior-generation and older but experienced teachers can be reluctant to adopt the use of technology merely because they have successfully been teaching for several years and might not always see the added value that mobile and ubiquitous technologies can bring. A further reason can be their belief about the challenges that mobile and ubiquitous technologies bring and that it is time consuming. Some of these teachers need to be convinced of why they need to change their whiteboard to an interactive whiteboard: they need it to be "much more" than what they already have, as said by one of the practicing teachers in the LETS GO project. The final group is, (4), the teachers that are not extra enthusiastic or non accepting, just following the evolution, and can be any type of teacher at any stage of their profession. The teachers' perceptions and attitude towards the use of mobile and ubiquitous technology in their professional lives do not represent or symbolize their perception and attitude towards use of mobile and ubiquitous technologies outside of their profession and in their private lives.

In the upper right of the rich picture are several arrows and these represent influencing factors from outside the formal educational system. The golden arrows are private aspects while the orange represent public aspects and the thicker, light pink arrow represent a broader, higher level of aspects influencing both the private and the public arrows. As society has evolved, the greater influence and importance of mobile and ubiquitous technology on the formal and informal role of the teacher has also altered and changed. The teachers have gone from having great authority and being the main and only source of knowledge standing in front of a passive, listening school class, and teaching a pre-set curriculum (e.g. Patcher et

al., 2010; Gärdenfors, 2010) to become questioned about and having to rethink their roles. Today, teachers are asked to move from the preached source of knowledge to involving the students in their own learning and to become facilitators and moderators of knowledge (e.g. Laurillad, 2009). Students today, as mentioned in previous pictures, have wider and greater opportunities for informal learning which they bring to their classrooms and can in some or many aspects be ahead of their teachers when dealing with mobile and ubiquitous technologies. This can be for some teachers intimidating, not to be superior and not having "full control", while other teachers embrace this opportunity to make the teaching and learning more interactive and take it to another level. The parents of the students also influence the teachers. Media and society, separately, represent and portray the teachers and their profession in various ways, affecting the parents and also the teachers directly and indirectly. The authority and the needs of teachers have in some cases been questioned (OECD, 2010), affecting the teachers' professional environment and thereby affecting the role of the teachers as teachers.

A highly influential factor affecting the teachers is their own private life and their own children who might be going to school, have been in school or will in the future be school students. For example, in the dedictive thematic analysis one practicing teacher from the LETS GO project explains how her/his children influence and help her/him with the use of technology. Further as argued in related research concering informal learning settings for students (Marcelo et al., 2013; Pachler et al., 2010), this can also be applied for teachers, and also prospective teachers. Moreover, the thematic analyses in relation to the prospective teachers make it reasonable to draw the conclusion that the background of the teachers influences and affects their identity and roles as teachers. All teachers have an underlying reason for becoming teachers and what they think the profession is all about. Hence teachers have always supposed to be the ones that possess all the knowledge. This presopotision now needs to be rethought due to the wide use of mobile and ubiquitous technologies in and outside of school settings (Dewey, 1929; Sharples et al., 2007). Additionally, teachers are influenced by other colleagues, from the four groups mentioned above.

Within the formal environment the teachers are being pushed and limited rather than being directly influenced. The teachers are obliged to follow the School Act 2010:800 and Lgr11 created, decided upon and provided by the Swedish Government and National Agency of Education, as illustrated in the bottom right of the picture (for more detailed description see description for Figure 6.2.1). Within the Lgr11 it is stated that teachers and students should use "modern technology" (Skolverket, 2011) although there are no guidelines or strategies on how this is to be done (Skolinspektionen, 2012). This, in combination with all the changes in the surroundings of the teachers, means the teachers are in need of new pedagogical models including novel use of mobile and ubiquitous technologies (see left side of Figure 6.4). The necessary pedagogical models should complement the existing pedagogical models used by the teachers as well as apply to the different pedagogical- and learning theories. Further, there is a need for the pedagogical models to include the new skills and literacies required from the working environment (see bottom left side of Figure 6.4). The subject matter is an additional aspect which needs to be taken into consideration for the new technology-enhanced pedagogical models.

As a consequence of the desire, requirement, and need for new pedagogical models, the teachers need education and training to use the mobile and ubiquitous technologies in novel ways based on the new technology-enhanced pedagogical models. This is a challenge due to the lack of time the teachers are experiencing, mainly because of tasks other than teaching,

such as administrative and other paper work, as mentioned in the deductive analysis as well as in reports from public authorities.

At the bottom of the teachers' rich picture, the classroom and the existence of technology is illustrated as a Interactive Whiteboard, and a student and a teacher with a laptop. The municipalities via the government do provide and implement to some extent mobile and ubiquitous technologies in schools, as discussed in previous pictures, although they are used in limited ways and not to their full extent and potential (Christiansen et al., 2008; Laurillard, 2009; Pachler et al., 2010, Skolinspektionen, 2012). Within schools, the computers are mainly used as typewriters and a source for finding information and interactive whiteboards are mainly used as regular whiteboards and only sometimes used to show pictures and movies (Thullberg & Szekley, 2009; Skolinspektionen, 2012). For the teachers to be able to use mobile and ubiquitous technologies in novel ways in their everyday teaching they need more than the technological devices. As mentioned above, there is need for technologically-enhanced pedagogical strategies as well as new technology-enhanced pedagogical models. Additionally, there is need for technical support. The construct, facilitating conditions, in the deductive thematic analyses illustrated the great importance of reliability and sustainability of the technology as well as the ease of use, although they need to have additional support when needed in order for the mobile and ubiquitous technology to become part of everyday teaching and learning practices and not an additional burden.

A further challenge, identified in the thematic analysis, for the teachers is the students. Large student classes makes teaching a greater challenge, especially in tasks where students are asked to be more active and, for instance, present and discuss in front of the class at the interactive whiteboard, such as in the Collboard project. To engage a full class of approximately 20 to 30 students would be a challenge for the teachers, making sure all have their turn at the whiteboard to present what they have done in the limited class hours. Other challenges can be teaching outdoors, keeping track and control of all students, such as in the GeM and LETS GO projects. These challenges were mainly mentioned in consideration of larger class sizes and tougher student groups.

As mentioned, teachers are central within this complex situation and they are influenced and challenged in several related ways. What also needs to be taken into consideration in this complex situation are the teachers-to-be, the individuals who are studying to take the role as teachers. The next section will present the perspective of the prospective teachers.

6.1.3 The Prospective Teachers

The teachers-to-be are the actors that are indirectly part of the complex situation. The influence the prospective teachers have on the complex situation is not much, although they can bring new insights to practicing teachers when they are at schools for practice studies. However, the complex problematic situation is highly relevant for the prospective teachers as they will become the teachers in the schools.

Figure 6.5 illustrates the complex situation from the perspective of the prospective teachers. Similar arrows such as the ones for the teachers can be identified for the prospective teachers, in the top left side of the picture. The prospective teachers also have

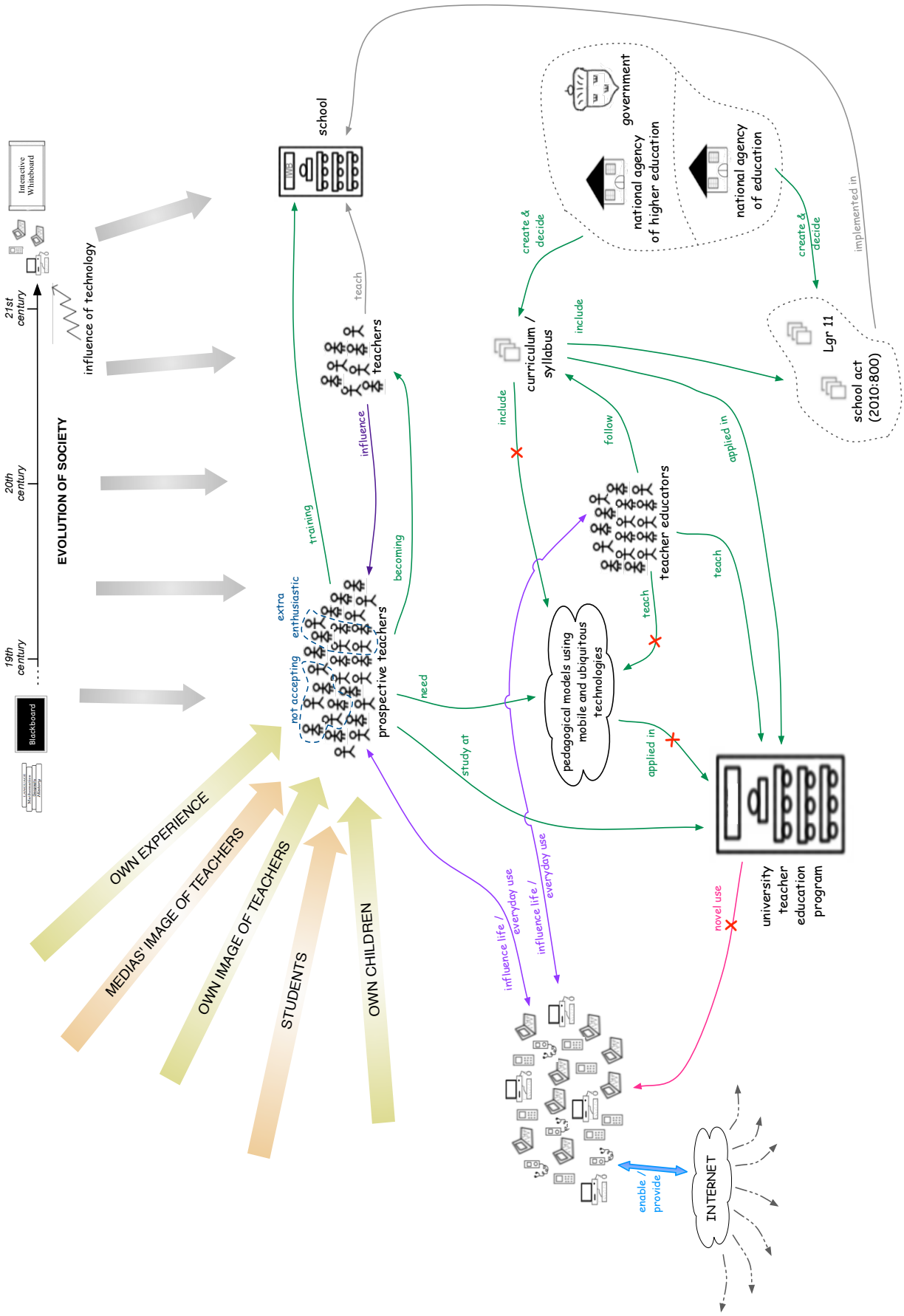


Figure 6.5 The Prospective Teachers Picture

aspects and factors influencing their roles as professionals: private, illustrated by golden arrows, and public, illustrated by orange arrows. The society and media image and representation of teachers and the teaching profession together with how students perceive and see teachers are public factors which influence the view prospective teachers have of the role of the teachers. Further the prospective teachers have their own image and experience of what a teacher is and how they are supposed to work. As mentioned by Dewey (1929), the judgment and worth of teachers are often based on the results of the students and for prospective teachers want in their education to learn how to teach to best attain good results. Some prospective teachers were in school when the teachers still had more authority and stood in front of a passive class with a chalk and blackboard while some prospective teachers might have came across the use of mobile and ubiquitous technologies in their own school learning. This can affect how they believe a teacher should be and thereby what role mobile and ubiquitous technologies could or should have in everyday teaching and learning. As seen in the thematic analsysis: some prospective students see themselves using such technologies in their own teaching in the future; they believe it is important to meet the students in their interests and daily lives. However, the prospective teachers were not able to see in what way the mobile and ubiquitous technologies could be used in their own subject matters. After seeing the possibilities of how mobile and ubiquitous technologies could be adopted and used in different subject matters, the novel use for them became clearer.

As in previous rich pictures, the green arrows indicate the formal educational setting. In the bottom left of the picture the Swedish Government, the National Agency of Higher Education and National Agency of Education is illustrated. The teacher education programs' curriculum and course syllabuses are created and decided upon by the National Agency of Higher Education together with the Government. What the prospective teachers said they lack in their education is learning how to use mobile and ubiquitous technologies within education. Technology-enhanced pedagogical models are missing on how teaching can be conducted with mobile and ubiquitous technologies and also how to respond to the requirements in the School Act and Lgr11. The prospective teachers lack the use of mobile and ubiquitous technologies in their own learning, as referred to by OECD (2010) and by participants this study. OECD (2010) also claimed that in some cases there was a reluctant attitude from the teacher educators and programs, which in this study cannot be fully verified. The prospective teachers are also influenced in their roles as teachers in schools where they practice and learn from teachers and also by the mindset and environment of the school. Their perception of the school is that there is a low knowledge-base of the use of mobile and ubiquitous technologies and there are other priorities.

As with all previous actors, the private lives of the prospective teachers include everyday use of mobile and ubiquitous technologies and such informal learning will most likely not be covered by their formal education program.

6.2 Summary of the Holistic Analysis and Discussion

This chapter applied Rich Pictures of Soft Systems Methodology to illustrate the complex problematic situation of novel use of mobile and ubiquitous technologies in education as a whole, including the perspective of the students, the teachers, and the prospective teachers.

The complex situation consists of actors, roles and entities influencing and being influenced by one another. The novel use of mobile and ubiquitous technologies in compulsory school is influenced by the formal learning environment, consisting of authorities developing and providing policies; School Acts, curriculums etc; the opportunities and

challenges brought to the learning and teaching by the mobile and ubiquitous technologies; as well as the surrounding environment, such as working life and the evolution of society.

The students are the actors that are the beneficiaries of this complex problematic situation. The result of the research show that the students would benefit by the addition of gaining new literacies and skills, as needed in future soceity. Further, students learn in informal settings and are influenced by parents, siblings and friends in their everyday lives outside of school.

Teachers are the main actors in this complex situation as they are those who can and/or will use the technology in novel ways in their everyday teaching. The teachers also have to follow policies, curriculums, etc. as well as handle challenges that occur, such as dealing with large class sizes, lack of time, training and pedagogical models that include technology-enhanced learning. They are also influenced by their informal settings and the image society and media has of teacher role and profession.

The final actors identified in the holistic analysis and discussion are the prospective teachers. Although they do not directly influence the complex situation of using technology in novel ways to support everyday teaching, the prospective teachers are those who in the future will be teaching in the schools. There is a lack of technology-enhanced pedagogical models in their education. The prospective teachers are influenced by the teachers they meet during their education but also by their own experience and perception of the profession of a teacher. They are also influenced by society and their informal lives, experiences they bring with them to the school they will teach at in the future.

CHAPTER 7

Conclusion

This new medium will not "save the world" from disaster. Just as the book, it brings a new set of horizons and a new set of problems.

Alan C. Kay, 1972

Alan Kay and his vision of the Dynabook were mentioned in the introduction to this thesis. In his work, Kay pays tribute to the beloved book that for centuries has captured, stored and transmitted human knowledge, although, he continued, it may be time to add to the book and introduce a "better" book that is more active and is able to convey the excitement of thought and creativity (Kay, 1972). The intention of this study has not been to replace the book and traditional education; on the contrary, it is about building upon what already successfully exists. As Lankshear and Knobel state, without the "old literacies" and traditional education, there would no books, no authorship, or convergence of knowledge and research (Lankshear & Knobel, 2007) that take us to where we are today.

This chapter will present the final words of this thesis. The first section will recapitulate the aim of this study and conclude by answering the research questions posted in the introduction. The second concludes with a reflection upon the research approach.

7.1 Conclusions

The aim of this study has been to explore what aspects impact novel use of mobile and ubiquitous technologies in everyday teaching and learning by identifying the influencing factors as well as finding out what the opportunities and challenges brought by mobile and ubiquitous technologies consist of. The study has been driven by three research questions:

- *What factors influence the novel use of mobile and ubiquitous technologies to support teaching and learning practices?*
- *What opportunities do mobile and ubiquitous technologies bring to a learning environment?*
- *What are the challenges?*

In order to answer these questions and to achieve the aim, this study has drawn upon three locally-conducted projects and applied three analysis methods. The first analysis method was a Thematic Analysis, consisting of two approaches: (1) an inductive approach investigating the experiences of teachers and students; and (2) a deductive approach, investigating the perception and acceptance of teachers. Second, a Soft Systems Method was undertaken using Rich Pictures to create a holistic understanding of the complex situation as a whole.

The conclusions of this study can be summarized in two related parts:

Novel use of Mobile and Ubiquitous Technology as part of Everyday Teaching and Learning: School education as we know it today is to a large extent as it has been in the last centuries, with minor changes and modernization. On a political and, to some extent, organizational level there are investments and ongoing efforts to bring in and encourage the use of mobile and ubiquitous technology as part of everyday teaching and learning practices. However, this it is not enough and there are additional challenges from other influencing factors.

For teachers to be able to use mobile and ubiquitous technologies in novel ways as part of everyday teaching and learning there is a need of assurance and safety for them to lean on. On a national but also regional level there is a need for a strategy on how to implement, adopt and use mobile and ubiquitous technologies that goes further than purchase, administration and maintenance of the technological equipment in the schools. The Technology Enhanced Learning policy, TEL-policy should include development of pedagogical models including mobile and ubiquitous technologies with the opportunities it brings as well of how to handle challenges. Further, appropriate, frequent education and training for teachers should be provided and planned for, and also for those students who are not comfortable and/or do not have sufficient knowledge in use of mobile and ubiquitous technologies.

Pedagogical models are a factor influencing not only the novel use of mobile and ubiquitous technologies in every day school education but also in the teacher education programs, provided to the prospective teachers alongside traditional pedagogical models. Technology Enhanced pedagogical models should be based on a pedagogical and didactical approach that includes traditional teaching and learning theories and be in line with the new skills and literacies required from the society and working environments. To improve the teachers' acceptance and perception of mobile and ubiquitous technologies, the positive opportunities need to be highlighted and challenges addressed. Beside assurance of ease of use and existence of support, the teachers should be considered in the development, purchase and implementation of mobile and ubiquitous technologies.

The human factor is another factor influencing the adoption of novel use of mobile and ubiquitous technologies in everyday teaching and learning practices. The background, experience, personal life as well as their images as reflected by society, the changing roles, expectations and authority of the teacher as a profession all affect whether a teacher chooses to adopt mobile and ubiquitous technologies with enthusiasm, be forced to by changing times and by regulations, or to follow what is asked without objection or enthusiasm. It is

similar for students and the prospective teachers, bringing their everyday life into the classroom where traditional and novel teaching and learning takes place. For the students, one important issue to bear in mind is that, even if the many from young generation are self-confident, secure and knowledgeable in using mobile and ubiquitous technologies, it does not mean that they have developed skills and competencies that make them responsible, critical and creative users of these technologies. Hence, there is a need for everyday use of mobile and ubiquitous technologies in formal education to provide the needed knowledge, skills and literacies for the students to become successful in their future lives.

The influencing factors for the novel use of mobile and ubiquitous technologies to support everyday teaching and learning practices each consists of several interrelated parts which need to be taken into consideration and be understood. For school education there is a need for change, where we need to move from desk-based teaching with students repeating what the teachers says to an active, participative student learning where the teachers lead the teaching, motivating, explaining and exemplifying based on the real world and everyday life. With mobile and ubiquitous technologies, the teachers can and should make knowledge more grounded, graspable and connected to the everyday reality. This should be based upon the traditional education and the basic knowledge as we know it today and which is needed as a foundation for the knowledge the younger generation need for the 21st century, knowledge- and technology-driven society.

Mobile and Ubiquitous Technology – the Opportunities and the Challenges: With the evolution of mobile and ubiquitous technologies in society, people and their lifestyles have been given opportunities not predictable in the past. Although with opportunities, challenges arise; to have the possibility to always be connected and have the ability to work and study at all times have also blurred the borders between our private-, public- and professional lives, causing anxiety and stress of constantly being and not being available and online.

Within compulsory school education and everyday teaching and learning there are certainly opportunities and added values brought to the teaching and learning by use of mobile and ubiquitous technologies. To actively participate and be involved in the learning process has been one of the main added values mentioned by not only teachers but also scholars researching within the field of Technology Enhanced Learning and within pedagogics. To be able to discuss and collaborate is highly appreciated by the students and also considered important by the teachers. As the students collaborate and discuss, they work in a different way explaining things for themselves and getting things explained to them, which increases their understanding and learning. The discussion and collaboration enabled by mobile and ubiquitous technologies is on a higher level that in a traditional education and can be challenging to achieve. New Literacies and 21st century skills emphasize the importance of new ways of thinking, collaboration, creativity, and innovation, etc. to be taught as an addition to the traditional literacies and skills. With use of mobile and ubiquitous technologies these skills can be taught in a way that motivates and stimulates students and covers several learning elements as well as to some extent applying to the various learning styles students have. Mobile and ubiquitous technologies make learning more enjoyable and interesting but more importantly it can make teaching and learning reality based, more grounded and graspable and, thereby, increase the motivation that may lead to higher understanding and enhanced learning. With the use of mobile technology, any place can at any time become a classroom and learning can be taken into the real world and the everyday life of the students. Novel use of mobile and ubiquitous technologies enables

seamless learning, making learning possible at anytime and place where there is curiosity and interest. The borders of formal and informal learning can be further blurred and the experiences and knowledge gained in everyday life can be shared among the learners and, with the moderation and guidance of the teachers, be grounded in the formal education.

For the teacher, use of mobile and ubiquitous technologies can enable reduction of time for administrative work as they can, for instance, use preset templates for evaluating students. Further, the teacher when acting as facilitator and moderator of knowledge can focus their attention on the whole class in order to involve and encourage all students to participate. The teachers, instead of having their backs towards the class while writing on the whiteboard, can face their students and actively participate in their learning and make learning more enjoyable and graspable for the students. The teachers can also use mobile and ubiquitous technologies to collaborate and share knowledge and experience with other colleagues. This way the teachers can find new ways for teaching but also save time in terms of lesson planning and other administrative work.

The main challenge that affects the full use of mobile and ubiquitous technology is the lack of strategies, technology-enhanced pedagogical models and approaches for adoption and use of mobile and ubiquitous technologies in everyday teaching and learning. Due to this, several other challenges such as lack of proper, appropriate and frequent education and training arises and, further, the lack of time for the teachers to update their own pedagogy and find new and novel ways for teaching with mobile and ubiquitous technologies. Sustainability, reliability and ease of use of are further challenges affecting the teachers in using mobile and ubiquitous technologies, especially in novel ways. For mobile and ubiquitous technologies to become part of everyday teaching and learning, the technology needs to be accountable and there is a need for IT support to be at the school when needed. To not be able to count on the technology or not have access to help and support are major challenges limiting the use of mobile and ubiquitous technologies. Further challenges influencing the teachers are the students as such as well as their relation to the mobile and ubiquitous technologies. Large class sizes are a challenge when using mobile and ubiquitous technologies in novel ways, such as when creating an active discussion with the students at a whiteboard. This could also apply for outdoor learning and teaching practices where it can be a challenge for a single or even two teachers to keep track of a whole class out in the environment, learning for instance, about ecology. There is also the issue of the students' informal knowledge of the use of mobile and ubiquitous technologies – how to harness it and how to deal with issues such as concentration and attention in class but also more serious issues such as new ways of cheating and bullying.

Despite the opportunities and added values brought by mobile and ubiquitous technologies the challenges have a greater influence on the adoption of novel ways to use mobile and ubiquitous technologies in everyday teaching and learning practices, preparing the students for 21st century society as well as fulfilling the requirements and goals in the School Act 2010:800 and Lgr11 set by the authorities.

7.2 Reflection of Methods, Methodologies and Research Projects

This study has had its basis on three projects conducted with local schools in Växjö, Sweden. Three analyses have been conducted on the empirical material in order to understand what factors influences the adoption and novel use of mobile and ubiquitous technologies in educational practices.

The Thematic Analysis approach was the initial analysis method used and which allowed for a considerable amount of data to be sorted and analyzed, both empirically and based on a theoretical approach. Applying an inductive approach based purely on the empirical data allowed the finding of patterns and categories across the three different projects. The inductive approach and the five categories identified covered the large part of the data across the projects and enabled a comprehensive understanding of the students' and teachers' experience of using mobile and ubiquitous technologies in educational settings. Although as the empirical data from the projects was not collected for the aim of this study, additional information could be identified which was not covered by the inductive thematic approach and thus a deductive analysis was conducted as well. The challenge with the inductive thematic analysis is the verification and definition of the identified themes. The theme Enhanced Learning is one of the themes which cannot be verified as this study cannot prove that the learning of the students was enhanced by the use of mobile and ubiquitous technologies in these projects. This finding is based on the experience of the teachers and the students who believed that they learned more by working in a novel way with the use of mobile and ubiquitous technologies. It is similar with the Fun theme that was mentioned by both teachers and students. The question to ask here is whether it was fun as it was different and new or if using mobile and ubiquitous technologies, even if within a project, was fun in the sense of enjoyment and is thereby in line with arguments from scholar such as Kay (1972). The validity and accuracy of the remaining themes, Collaboration, Advantages, and Disadvantages, is easier to ascertain partly due to observations that could be done by researchers participating but also with support from theoretical references.

The Unified Theory of Use and Acceptance of Technology, UTAUT, and the extended version of the model, UTAUT2, were used as a theoretical framework for the categories of the deductive thematic analysis. As the inductive thematic analysis did not cover all patterns identified in the empirical data constructs from UTAUT and UTAUT2, models were applied as themes in the second analysis. UTAUT is a model covering a wide range of aspects in relation to perception and acceptance of use of technology as is draws upon eight different models originating from different backgrounds and disciplines[31] (Venkatesh et al., 2003). UTAUT2 builds upon the UTAUT model. These models are mainly used for quantitative analysis while this study uses constructs from the UTAUT and UTAUT2 models for analysis of qualitative data. The four main constructs from the original model, one moderator and two of the constructs from the extended model were used. The main constructs; Performance Expectancy, Effort Expectancy, Social Influence, and Facilitating Conditions from the original model, which also is included in the extended version, as well as the constructs Hedonic Value and Habit, and the moderator Voluntariness of Use were chosen based on their definitions (see Table 4.1) as they were inline with the aim of this study. The Hedonic Value and Habit and Experience were patterns that could be seen in the inductive thematic analysis and could be considered influential for the teachers' perception and attitude towards novel use of mobile and ubiquitous technologies. However the models were, even after combining them (see Figure 4.3), not used to its full extent in the analysis of

[31] See chapter 4.2.

this thesis due to two reasons. The main reason is the static nature of the UTAUT models. The drawback of the UTAUT and UTAUT2 models is the lack of iteration between the core constructs but also the constructs and the predictors Behavior Intention and Use Behavior (see Figure 4.1, and Figure 4.2). In order to use the model to its full extent the Behavior Intention and Use of Behavior have to have a relation to the main constructs, as these predictors affect the constructs, in particular, Performance Expectancy and Effort Expectancy. Behavior Intention and Use Behavior influence the constructs which in return influence them in a reciprocal fashion. The UTAUT and UTAUT2 models lack iteration. Within the empirical projects in this study, as each trial consist of several sessions, it can be seen that Use Behavior influences Performance Expectancy and also Effort Expectancy and to some extent Experience and Habit and Voluntariness of Use. In the second iteration these changed constructs together with the other constructs, which remain the same, influences Use Behavior again. Hence, the perception, behavior and, to some extent, their attitude towards the technology changed after becoming familiar with the mobile and ubiquitous technologies. The second reason the UTAUT and UTAUT2 models were not used to their full extent was by not including Behavior Intention. The data collection neither aimed at nor included the intention of using mobile and ubiquitous technologies and, further, the aim of the analysis was to understand the acceptance and perception towards the use of technology. By identifying and looking into the different constructs, the effect could be seen in the actual use, that is the Use Behavior and not how the teachers intended, wished or planned to use the mobile and ubiquitous technologies. As Straub (2009) argues, the model covers much valuable and important information which can give an understanding of attitude and perception towards the use of technology. Additionally, he argues, despite the users, in this case the teachers, not having an choice in using technology, their standpoint towards the technology can be captured and can contribute to a more comprehensive, complete understanding of novel use of mobile and ubiquitous technology in teaching.

The core of this study is based on Soft Systems Methodology, SSM, and more specifically Rich Pictures. As SSM is based on the idea of parts, the whole and the relationships between them, comprehensive and complex pictures have been created, enabling an understanding of the complex situation. Rich Pictures have enabled the illustration of the complexity of an educational practice, with all the parts together within the whole. The different roles, actors, entities and relationships have been illustrated in an open and transparent manner. Within the complex picture (see Figure 6.2) several hierarchies and power relations exist and this cannot be illustrated in a simple comprehensive way in the picture and need to be explained with text which adds to the complexity of the holistic understanding of the complex situation. Beside the strength of illustrating the complexity of the various aspects influencing the use of mobile and ubiquitous technologies in everyday teaching and learning, SSM enables insight into several worldviews. Within this study the worldview of the students, teachers and prospective teachers were illustrated based on the empirical foundation but also theoretical perspectives addressed in the introduction and area of concern. The limitation in this study has been the challenge to present and discuss the viewpoint and worldview of the actual actors and roles without their full involvement and participation. In order to gain a full understanding of the complete worldview, a deeper insight is needed but also a need to follow the complete SSM learning cycle (see Figure 4.4), therefore, this analysis and discussion does not wish to speculate on, for example, tensions between different entities, roles, actors beyond those illustrated in the rich pictures.

The holistic analysis and discussion based on the inductive-, and deductive thematic analyses as well as the area of concern has enabled an understanding of influential factors in

the adoption of novel use of mobile and ubiquitous technologies in everyday teaching and learning. In addition, a wider understanding of the field of Technology Enhanced Learning has been achieved.

The three projects that this study draws upon, GeM, LETS GO, and Collboard, have been driven by technology design and development and the subject matters have varied. None of the projects was specifically designed for the purpose of this study. For each project, extensive data was collected in various different forms. For this study, the interviews, observations and surveys have enriched the empirical foundation and because they have been more in line with the aim of the study than other collected data, such as data logs, screen recordings, etc. The credibility of the results of this study could be questioned due to the collected data not being aimed for this research. However, it can be argued that, since the data was collected based on other research aims, the trustworthiness of the data can be assured and the interviewees have not given the answers they think the researcher wishes to hear. Further, the findings of the analyses of the empirical data have been in line with the literature and with governmental reports.

These limitations could impact the results; nevertheless the results are trustworthy and fulfill the aim of this study, identifying factors that influence the adoption and novel use of mobile and ubiquitous technologies, as well as identifying the added values and challenges.

CHAPTER 8

Contribution

This chapter will present the contribution of this study to the theory followed by the contribution to the research field of Technology Enhanced Learning. The chapter is finalized discussing future research based on the conclusions and the contribution of the thesis.

8.1 Contribution to Theory

User-acceptance models are used to enable us to gain an overview of how humans will perceive and act towards, in this case, technology. In this study, a technology-acceptance model, which builds upon eight different models, has been used as a source of inspiration in order to understand teachers' perception and acceptance of technology in their everyday profession.

Figure 8.1 attempts to illustrate the modified Unified Theory of Acceptance and Use of Technology as perceived in this study, with iterations. As mentioned in the previous section within the empirical investigation, it could be seen that the factors that influence the use of the mobile and ubiquitous technologies in a second encounter with the technology and being used once or twice, the initial influence of a factor could be modified.

The modified UTAUT model illustrates (see Figure 8.1) two sets of factors and Used Behavior predictors. The factors consist of Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions, Hedonic Motivation, Experience and Habit, Voluntariness of Use, as well as a miscellaneous factor labeled Other. As the factors are based on Venkatesh et al.'s (2003; 2012) UTAUT and UTAUT2 models, the definitions of the factors is the same (for the definitions see Table 4.1 and Table 4.2). The pillars with the numbers indicate the contingency of the flow, whereas "n" acts as infinite numbers in the iteration.

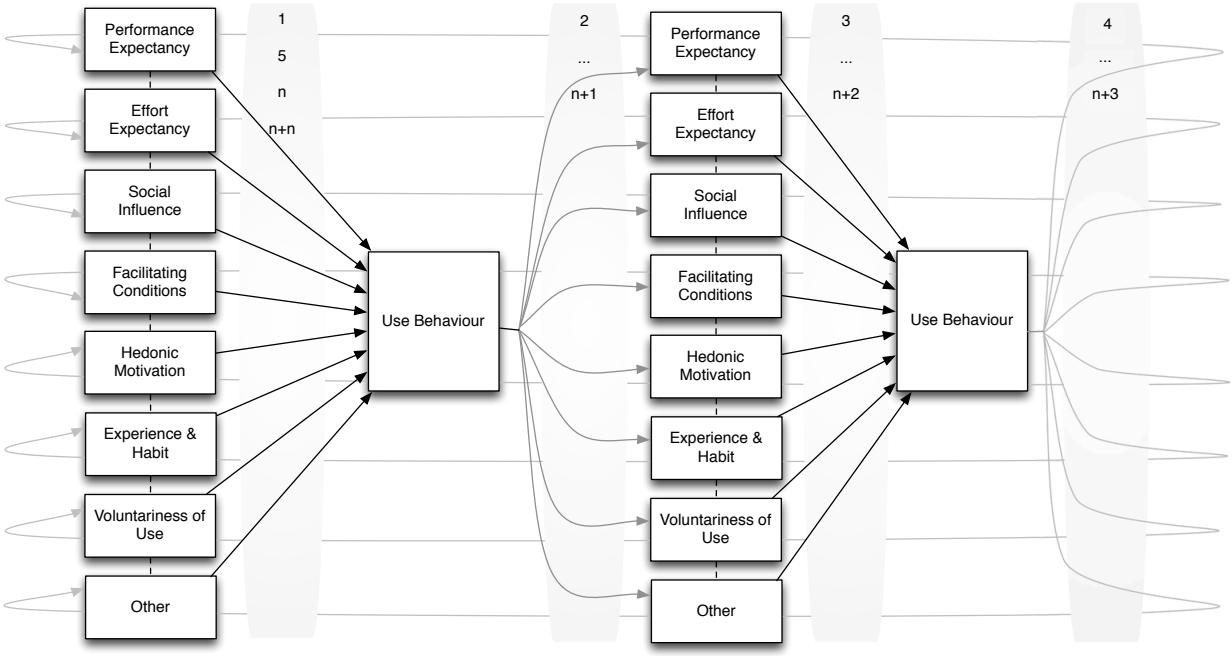


Figure 8.1 Modified Unified Theory of Acceptance and Use of Technology model (modified and adopted from Venkatesh et al., 2003;2012)

However it should be added that the impact the actual use has on the different constructs or factors varies depending on each case and for each iteration. As illustrated in Figure 8.1, it can be seen that all constructs influence Use Behavior and thereafter Use Behavior could affect all or some of the constructs, illustrated with gray arrows. In the deductive analysis in this study, as presented in previous section, Use Behavior affects all constructs beside Social Influences, Facilitating Condition and Other. In the second iteration and, as the third pillar illustrates, all factors once again influence Use Behavior, while the fourth pillar again has gray arrows indicating that some factors might be influenced. Within longitudinal studies and a number of iterations, the constructs will become stable and the influences from the factors and the use behavior will decrease.

It should also be considered that the complexity of educational practices is lacking in this model, as Straub (2009) argued about the UTAUT model; however, by adding iteration to the model, a higher lever of understanding can be achieved, enabling understanding of one part of the educational complexity.

8.2 Contribution to the field of Technology Enhanced Learning

In the initial chapter of this thesis, Dewey (1929) was referred to arguing for the complexity of educational practices and the importance of one factor only being able to be verified in balance with several other factors.[32] With the use of Soft Systems Methodology's Rich Pictures, the complexity of factors influencing novel use of mobile and ubiquitous technologies in everyday teaching and learning: the parts, the relationships between them

[32] See Chapter 1.1

and hence an understanding of the whole and thereby a higher understanding of the parts[33], as argued by von Bertalanffy (1972), has been achieved.

This study has illustrated the complexity of several related factors and challenges within the field of Technology Enhanced Learning. Kurti (2009) argued for Technology Enhanced Learning to consist of three domain challenges. He identified: (1) technology and engineering challenges; (2), design and interaction challenges; and (3) learning, social and cognitive challenges. Kurti argues that Technology Enhanced Learning consists of humans (i.e. the learners), technology which is referred to as different tools, resources and the interactions between them, as well as the setting where the learning takes place – referred to as organizational setting. Throughout this thesis these challenges, in a slightly different understanding, have been identified and it has also been shown that additional challenges can be added on to this model. An extension of Kurti's original model (2009, pp. 7) can be illustrated as in Figure 8.2.

The complex model of the challenges of the Technology Enhanced Model consists of the three domain challenges identified by Kurti (2009) at the bottom of the figure (see Figure 8.2), and three additional challenges added to the top, as well as a general overall cloud covering all parts. The additional challenges added to the original model consist of: Political challenges, Organizational challenges and Resources as a separate challenge to be addressed. Society has also been added to the model as an overall challenge covering the different challenges and the field as a whole. Additionally, for each challenge, a number of factors have been identified and listed as examples based on the results of this study.

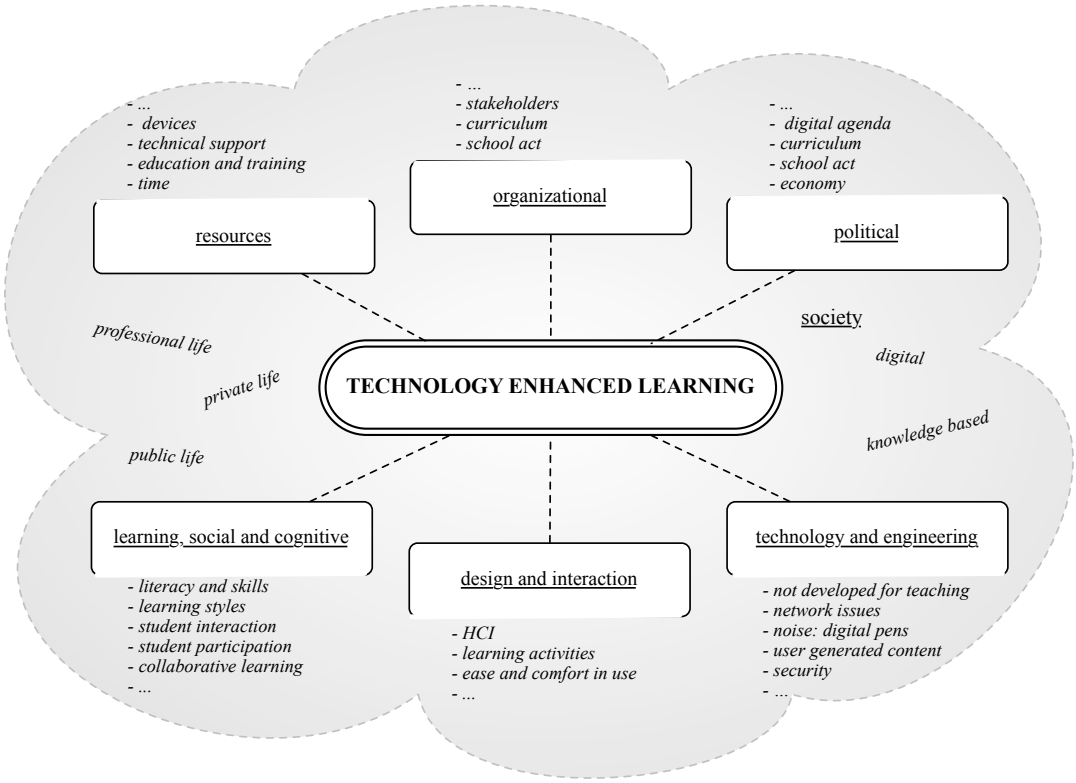


Figure 8.2 Challenges of Technology Enhanced Learning; the complex model (extended and adopted from Kurti, 2009)

[33] See Chapter 3

All these challenges directly and indirectly influence the field of Technology Enhanced Learning. What is also important to bear in mind is not only the different parts but also the relations between them and their impact on one another. Within this figure the relations between the different challenges has been illustrated through the Society cloud. As the challenges are part of the society, they are all being influenced by society but also influenced by one another within the society and ultimately the field as such.

At the bottom left of the model is Learning, Social and Cognitive. These challenges are mainly concerned with the pedagogical and didactical issues of Technology Enhanced Learning. Beside new literacies and skills which need to be addressed, the challenge of the learning styles of the students and the teaching styles of the teachers need to be taken into consideration. A further challenge is considering issues such as collaboration and participation via discussions. Design and Interaction covers challenges such as the learning activity: how a learning activity consisting of mobile and ubiquitous technologies with a full class of, for instance 28 students, should be designed in order to achieve collaboration, active student involvement, discussions and, thereby, enhanced learning and understanding. This challenge was mentioned by one of the Collboard teachers. Further, there is the challenge of interaction with the mobile and ubiquitous technologies; factors that impact the field as a whole. This is related to the Technology and Engineering challenge where technology is not always developed for teaching with teachers and students in mind. Although there are technologies specifically developed for educational purposes, we are not completely there yet. There are also issues such as the accuracy and reliability of the technologies, which to some extent were identified as challenges where students have had problems with the GPS, the digital pens, etc.

The three challenges presented at top of the model could be seen as external challenges within the field of Technology Enhanced Learning. The political challenges affect the field in terms of regulations, policies, curriculums, which need to be developed with Technology Enhanced Learning and all its parts in mind and followed by the schools as organizations. Further, the political challenges include economic aspects. This, together with the organizational challenges, affects the resources, illustrated in the top right corner, in terms of equipment but also technical support, training and education for both teachers and students and the critical challenge of time. Time as resource is a major challenge for the teacher. The teachers have to balance the time to update their pedagogical models to include mobile and ubiquitous technologies. The time also has to cover the training they need, which to a large extent today has to be done by the teachers in their leisure time with very little support from the organization and without political guidelines. This is a resource challenge in terms of time for actual teaching. The teachers in the Collboard project mentioned lesson time to be an issue, including the hours of administrative work, which is increasing for the teachers.

A further challenge that has not been added to the model and that was mentioned by Kurti (2009) is the role of humans. The humans and their roles, distinguished by Checkland (Checkland & Poulter, 2006), are not a challenge to the field of Technology Enhanced Learning per se but have a great impact and influence on the adoption and use. The experiences, perceptions and attitude towards use of mobile and ubiquitous technology by the different teachers and students are important to bear in mind as part of the Technology Enhanced Learning field, both as individual humans but also within their roles as teachers and students.

8.3 Future Research

In 1929 Dewey claimed that the reality of education cannot be found in books, laboratories or in the classrooms where teaching and learning take place but in the mind and thoughts of those who are engaged in the educational practices (Dewey, 1929). In order to understand educational practices and exploring how novel use of mobile and ubiquitous technologies can effortlessly be part of everyday teaching and learning within school education further research is necessary. This study has shown that educational practice is complex, consisting of several actors, roles, entities, and relations, all with different power- and influencing effects, where each one affects and influences others within the whole and the actual whole. For teaching and learning to use mobile and ubiquitous technologies in novel ways to support everyday teaching and learning, these parts and influencing factors need to taken into consideration as parts and as a whole. Hence, there will not be any single, simple path to take for future research but the need for a multi-disciplinary and multi-leveled approach.

Two branches of research for the future could be in taking a step back from this study and exploring the mindsets of the teachers and students: to be able to identify what learning is for teachers; what their everyday profession looks like; and exploring the identity of the teachers based on their own worldview but also from the outside. Second, a deeper study into the policies, strategies and pedagogical models existing and absent in the educational practices today and how they could be developed, implementing Technology Enhanced Learning and adopting it to the changing society. By believing teachers will adopt and use technology purely because it to some extent exists in the classrooms would be too simple solution to a complex issue. The educational practices need to move beyond purchasing equipment, which students and teachers can do by themselves if they wish, to focus on the factors influencing its adoption and support for the users, based on their worldview how it can be used in a beneficial way in educational practices.

This thesis is based on three projects in Växjö, Sweden, and gives an insight into what factors influence the novel use of mobile and ubiquitous technologies as part of everyday educational practices, and, while it therefore cannot been seen as a general study, it would be of great interest to do a similar study in a larger context, following the complete SSM Learning Cycle. Further, an interesting issue to address is whether these research projects remain just projects and what happens after a project has been conducted, for a short or longer term, at a school with the existence, and support of researchers. Could these projects affect the teachers in adopting novel use of mobile and ubiquitous technologies and how they conduct their everyday teaching?

For the future, regardless of direction, we need to bear in mind that information and knowledge can be gained through everyday life, thanks to the opportunities provided by mobile and ubiquitous technology, but what traditional education provides cannot be replaced by technology. However, compulsory school education as we know it today needs to sharpen up and meet society and everyday life and reality of the students and the teachers.

Bibliography

Alvarez C., Nussbaum M. and Milrad M. (2010). 'Collboard: Supporting New Media Literacies and Collaborative Learning Using Digital Pens and Interactive Whiteboards', Proceedings of *The 18th International Conference on Computers in Education.* Putrajaya, Malaysia: Asia-Pacific Society of Computers in Education

Alvarez C., Salavati S., Nussbaum M. and Milrad M. (2013) 'Collboard: Fostering New Media Literacies in the Classroom through Collaborative Problem Solving Supported by Digital Pens and Interactive Whiteboards', *Computers in Education.*

von Bertalanffy L. (1972) The History and Status of General Systems Theory, *The Academy of Management Journal.* 5(2), pp. 407-426

Binkley M., Erstad O., Herman J., Raizen S., Ripley M., Miller-Ricci M., and Rumble M. (2012) Defining Twenty-First Century Skills In Griffin, P., McGaw, B. & Care, E. (eds.). *Assessment and Teaching of 21st Century Skills*. (pp.17-66) Dordrecht: Springer Netherlands

Bradley G. (2006a) Social Informatics – From Theory to Actions for the Good Society. In IFIP International IFIP International Federation for Information Processing, Volume 223, Social Informatics: An In- formation Society for All? In Berleur, T., Numinen, M. I., Impagliazzo, J. (eds) *Remembrance of Rob Kling* (pp. 383-394), Boston: Springer.

Bradley G. (2006b) *Social and Community Informatics - Humans on the Net*, London: Routledge

Bradley G. (2010), The Convergence Theory on ICT, Society and Human Beings – Towards the Good ICT society, *tripleC,* 8(2), pp. 183-192

Boyatzis R. E. (1998) Transforming qualitative Information – Thematic Analysis and Code Development, California: SAGE Publications. Inc.

CeLeKT (2011) Center for Learning and Knowledge Technologies, Sweden, Växjö, [Online] Available at: http://www.celekt.info [Accessed: 2011-11-15]

Centrum för Marknadsanalys (CMA) (2009) *"Internet och lärarutbildningen: Om lärarstudenters och lärarutbildares attityd till och användning av IT",* Sotckholm/Lindköping: Centrum för Marknadsanalys

Checkland P. (1999) *Systems Thinking, Systems Practice: Includes a 30 year Retrospective*, Chichester: John Wiley & Sons

Checkland, P. (2000) Soft Systems Methodology: A Thirty Year Retrospective. *Systems Research and Behavioral Science*, 17, pp. 11–58

Checkland, P. (2011) Systems Movement: Autobibliographical retrospectives. *International Journal of General Systems*, 40(5), pp. 487–512

Checkland, P. and Poulter J. (2006) *Learning for Action: A Short Definitive Account of Soft Systems Methodology and its use for Practitioners, Teachers and Students,* Chichester: John Wiley & Sons

Checkland, P. and Poulter J. (2010) Soft Systems Methodology. In: Reynolds M. and Holwell S. (eds.) *Systems Approaches to Managing Change: A Practical Guide*. London: Springer, pp. 191-242.

Checkland P. and Winter M. (2006) Process and Content: Two ways of Using SSM, *The Journal of the Operational Research Society,* 57(12), pp. 1435-1441

Churchman, C. W. (1971) *The Design of Inquiring Systems.* New York: Basic Books

Christensen, M. C., Horn B. M., and Johnson W. C. (2008) *Disturbing Class: How Disruptive Innovation Will Change the Way the World Learns*, USA: McGraw-Hill

Creswell J. W. (2009) *Research design – Qualitative, Quantitative and Mixed Method Approaches*. (3rd Edition). USA: SAGE Publications. Inc.

Davis, F. D. (1989) Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology, *MIS Quarterly*, 13, 318-340

Dewey, J. (1929) The Sources of a Science of Education, *The Kappa Delta Pi Lecture Series* New York: Horace Liveright

Dillenbourg, P., Järvelä, S. and Fischer, F. (2009). "The evolution of research on computer-supported collaborative learning: from design to orchestration". in Balacheff, N., Ludvigsen, S., de Jong, T., Lazonder, T.A. and Barnes, S. (eds.), *Technology-enhanced learning: Principles and products*, (pp. 3-19.), Netherlands: Springer

Eliasson, J., Spikol, D., Pargman, T. and Ramberg, R. (2010), 'Get the bees away from the hive: Balancing visual focus on devices in mobile learning', in *IADIS International Conference Mobile Learning 2010*, Porto, Portugal

Flood, J. and Jackson, M. C. (red.) (1991). *Critical systems thinking: directed readings*. Chichester: Wiley

Forrester J. W. (1994), Systems Dynamics, Systems Thinking and Soft OR, *Systems Dynamics Review*, 10(2), pp. 245-256

Gil de la Iglesia, D. (2012) *Uncertainties in Mobile Learning applications: Software Architecture Challenges,* Licentiate, Linnaeus University School of Computer Science, Physics and Mathematics, Växjö: Linnaeus University Dissertations

Griffin, P., McGaw, B. and Care, E. (2012a). *Assessment and Teaching of 21st Century Skills*. Dordrecht: Springer Netherlands

Griffin, P., Care, E. and McGaw, B. (2012b). The Changing Role of Education and Schools. In Griffin, P., McGaw, B. & Care, E. (eds.). *Assessment and Teaching of 21st Century Skills*. (pp.1-16) Dordrecht: Springer Netherlands

Gärdenfors, P. (2010) *Lusten att förstå: Om lärande på människans villkor,* Stockholm: Natur & Kultur

Harper, R., Rodden T., Rogers Y., and Sellen A. (2008) *Being Human: Human-Computer Interaction in the year 2020*, England: Microsoft Research Ltd

Hennington A., Janz, B., Amis, J., and Ernest, N. (2009) Information Systems and Healthcare XXII: Understanding the Multidimensionality of Information Systems Use: A Study of Nurses' Use of a Mandated Electronic Medical Record System, *Communication of the Association for Information Systems,* 25, pp. 243-262

Jackson, M. C. (2003) *Systems Thinking: Creative Holism for Managers*, Chicherster: John Wiley & Sons

Jackson, M. C. and Keys, P. (1984) Toward a System of Systems Methodologies, *The Journal of Operational Research Society*, 35, pp. 473-486

Jenkins, H., Clinton, K., Purushotma, R., Robison, A.J. and Weigel, M. (2006). *Confronting the Challenges of Participatory Culture: Media Education For the 21st Century,* [Online] Chicago: The MacArthur Foundation. Available at: http://www.newmedialiteracies.org/files/working/NMLWhitePaper.pdf/ [Accessed: 2012-01-06]

Jenkins, H., Clinton, K., Purushotma, R., Robison, A.J. and Weigel, M. (2009). *Confronting the Challenges of Participatory Culture: Media Education For the 21st Century,* [Online] Chicago: The MacArthur Foundation. Massachusetts: The MIT Press. Available at: http://mitpress.mit.edu/sites/default/files/titles/free_download/9780262513623_Confronting_the_Challenges.pdf [Accessed: 2012-12-01]

Johnson, L., Smith, R., Willis, H., Levine, A., and Haywood, K., (2011) *The 2011 Horizon Report.* Austin, Texas: The New Media Consortium

Kay A. C. (1972). 'A personal computer for children of all ages', *Proceedings of the ACM national conference.* Xerox Palo Alto Research Center.

Kay A. and Goldberg, A. (1977), 'Personal Dynamic Media', *Computer*, vol 10 (3), pp. 31–41.

Kay K. and Greenhill V. (2011) Twenty-First Century Students Need 21st Century Skills. In Wan G. and Gut D. M. (eds.), *Bringing Schools into the 21st Century,* (pp. 41-65) Dordrecht: Springer Netherlands

Keller C. (2007) *Virtual Learning Environments in Higher Education: A Study of User Acceptance*, Ph.D., Lindköping University: Department of Management and Engineering

Kurti A. (2009) *Exploring the multiple dimensions of context: Implications for the design and development of innovative technology-enhanced learning environments,* Ph.D., Växjö: Växjö University Press

Ladyman J. (2002) *Understanding Philosophy of Science*, Routlegde, London: UK

Lankshear C. and Knobel M. (2006) *New Literacies: everyday literacies and classroom learning.* Second Edition, Maidenhead, New York: Open University Press

Lankshear C. and Knobel M. (2007) Researching New Literacies: Web 2.0 practices and insider perspectives. *E-learning*, 4(3), pp. 224-240

Lankshear C. and Knobel M. (2011) *New Literacies: everyday literacies and classroom learning.* Third Edition, Maidenhead, New York: Open University Press

Laurillard D. (2008) Technology Enhance Learning as a Tool for Pedagogical Innovation. *Journal of Philosophy of Education,* 42(3-4), pp. 521-533

Laurillard D. (2009) The pedagogical challenges to collaborative technologies. *International Journal of Computer Supported Collaborative Learning (ijCSCL),* 4(1), pp. 5-20

Lebo H. et al. (2012) *World Internet Project International Report (Third Edition),* Center for the Digital Future, US: USC Annenberg School for Communication & Journalism

Lärarnas Riksförbund [34] (2010), *Elever och lärare online – var går gränssen?* Stockholm: Lärarnas Riksförbund [Online], Available at: http://www.lr.se/download/18.4ff660ce12b12fe7dbb80003310/Rapport+Elever+och+l%20ärare+online.pdf [Accessed: 2013-02-10]

[34] The National Union of Teachers

Milrad, M., Wong, L.H, Sharples, M., Hwang G.J., Looi, C. and Ogata, H. (2013) Seamless Learning: An International Perspective on Next Generation Technology Enhanced Learning. In Berge Z. L. & Muilenburg L. Y (eds.), *Handbook of Mobile Learning, (*pp. 95-108) New York: Routledge

Mingers J. (1986) Applying the Soft Systems Methodology (SSM): An Example "In the Raw", *Systemist* 22

Mingers J. and Taylor S. (1992) The Use of Soft Systems Methodology in Practice, The *Journal of Operational Research Society*. 43(4), pp. 321-332

Mirijamdotter, A. and Somerville, M.M. (2009). Collaborative Design: An SSM-Enabled Organizational Learning Approach. I*nternational Journal of Information Technologies and the Systems Approach*, 2(1), pp. 48-69.

Moore, G. C. and Benbasat, I. (1991) Development of an Instrument to Measure the Perceptions of Adopting an Information Technology Innovation, *Information Systems Research*, 2, pp. 192-222

Naismith L., Lonsdale P., Vavoula G. and Sharples M. (2004) *Report 11: Literature Review in Mobile Technologies and Learning*, Futurelab Series, University of Birmingham

Nilsson, P., Sollervall, H. and Spikol, D. (2010), 'Mathematical learning processes supported by augmented reality', *Proceedings of the 34th Conference of the International Group for the Psychology of Mathematics Education* (PME) held in Bello Horizonte, Brazil, July 2010

Näringsdepartimentet[35] (2011) *ICT for Everyone – A Digital Agenda for Sweden*, 2011, (N2011.19) Stockholm: Ministry of Enterprise, Energy and Communications [Online], Available at: http://www.regeringen.se/sb/d/108/a/181801 [Accessed: 2012-11-27]

Organisation for Economic Co-operation and Development (OECD), (2010) *Inspired by Technology, Driven by Pedagogy: A Systemic Approach to Technology-Based School Innovations*, Paris:OECD Publishing

Oxford Dictionaries (2010) Oxford Dictionaries. April 2010. Oxford University Press.

Oye, N. D., Iahad, A., and Rahim, N. (2012) The history of UTAUT model and its impact on ICT acceptance and usage by academicians. *Education and Information Technologies*, (pp. 1–20) US: Springer

Pachler, N., Bachmair, B., and Cook, J. (2010). *Mobile Learning: Structures, Agency, Practices*, New York, Dordrecht, Heidelberg, London: Springer

Pea, R., Milrad, M., Maldonado, H., Vogel, B., Kurti, A., and Spikol, D. (2012). 'Learning and Technological Designs for Mobile Science Inquiry collaboratories.' in K. Littleton, E. Scanlon and M. Sharples. (eds.), *Orchestrating Inquiry Learning*, London: Routledge

Reynolds, M. and Holwell, S. (2010). Introducing Systems Approaches. In Reynolds, M. and Holwell, S. (eds.) *Systems Approaches to Managing Change: A Practical Guide*, (pp. 1–23.) London: Springer

Salavati S. and Mörtberg C. (2012a) *Researching Innovative Educational Practices: Exploring the Use of Mobile and Ubiquitous Technologies,* The 35th Information Research Seminar in Scandinavia (IRIS 2012), Sigtuna: Sweden

[35] Ministry of Enterprise, Energy and Communications

Salavati S. and Mörtberg C. (2012b) *Researching Innovative Educational Practices: Experiences of Mobile and Ubiquitous Technologies*, Selected Papers of the Information Systems Research Seminar in Scandinavia Nr. 3 (2012): IRIS 35 Designing the Interactive Society, Sigtuna: Sweden

Scardamalia M., Bransfordm J., Kozmam B. and Quellmalzm E. (2010) *New assessments and environments for knowledge builders,* The University of Melburn

SFS 2010:800. *Skollag.* Stockholm: Utbildningsdepartimentet [Online], Available at: http://www.riksdagen.se/sv/Dokument-Lagar/Lagar/Svenskforfattningssamling/Skollag-2010800_sfs-2010-800/#K10 [Accessed: 2012-11-27]

Sharples, M., Taylor, J., and Vavoula, G. (2007). 'A theory of learning for the mobile age', in, R. Andrews, and C. Haythornthwaite (eds.), *The Sage handbook of e-learning research, (*pp. 221–247.) London: Sage Publications Ltd

Skolinspektionen [36] (2011) *Litteraturöversikt för IT-användning i undervisningen*. (Dnr 40-2010:5753) [Online], Available at: http://www.skolinspektionen.se/documents/kvalitetsgranskning/it/litteraturoversikt-it.pdf [Accessed: 2012-11-27]

Skolinspektionen (2012) *Satsningarna på IT används inte i skolornas undervisning*. (Dnr 40-2011:2928) [Online], Available at: http://www.skolinspektionen.se/Documents/Kvalitetsgranskning/it/pm-it-iundervisningen.pdf [Accessed: 2012-11-27]

Skolverket[37] (2011) *Curriculum for the compulsory school system, the preschool class and the leisure-time centre 2011* (Lgr11), Stockholm: Skolverket. [Online], Available at: http://www.skolverket.se/publikationer?id=2687 [Accessed: 2012-11-27]

Skolverket (2013) *It-användning och it-kompetens i skolan*, [Online], Available at: http://www.skolverket.se/publikationer?id=3005 [Accessed: 2013-06-22]

Sollervall, H., Nilsson, P. and Spikol, D. (2010), 'Augmented reality as support for designing a learning activity concerning the mathematical concept of scale'. *Proceedings of the 34th Conference of the International Group for the Psychology of Mathematics Education* (PME) held in Bello Horizonte, Brazil, July 2010

Sollervall, H., Gil, D., Milrad, M., Petersson, O., Salavati, S. and Yau, J. (2011a). 'Trade-offs between didactical and technological design requirements affecting the robustness of a mobile learning activity'. *Proceedings of The International Conference on Computers in Education*, ICCE 2011 held in Chiang Mai, Thailand, November 28th-December 2nd, 2011

Sollervall, H., Gil, D., Milrad, M., Peng, A., Petersson, O., Salavati, S. and Yau, J. (2011b). 'Designing with mobile technologies for enacting the learning of geometry'. *Workshop Proceedings of the 19th International Conference on Computers in Education*, ICCE2011

Somerville, M., Mirijamdotter, A., and Collins L. (2006) Systems Thinking and Information Literacy: Elements of a Knowledge Enabling Workplace Environment. *Proccedings of the 39th Hawaii International Conference on Systems Sciences*

Spikol, D. (2010). *A Design Toolkit for Emerging Learning Landscapes Supported by Ubiquitous Computing*, Linnaeus University School of Computer Science, Physics and Mathematics, Växjö: Linnaeus University Dissertations

[36] The Swedish School Inspectorate

[37] The National Agency of Education

Stahl, G., Koschmann, T., and Suthers, D. (2006) Computer-supported collaborative learning: An historical perspective. In R. K. Sawyer (eds.), *Cambridge handbook of the learning sciences,* (pp. 409-426) Cambridge: Cambridge University Press

Stowell F. and Welch C. (2012) *The Manager's Guide to Systems Practice: Making Sense of Complex Problems,* Chichester: John Wiley & Sons Ltd

Straub E. (2009) Understanding Technology Adoption: Theory and Future Directions for Informal Learning. *Review of Educational Research,* 70(2), pp. 625-649

Thullberg P. and Szekely C. (2009) *Redovisning av uppdraget att bedöma verksamheters och huvudmäns utvecklingsbehov avseende IT-användningen inom förskola, skola och vuxenutbildning samt ge förslag på insatser.*, Stockholm: Skolverket

Thullberg P. and Millstam P. (2010) *Redovisning av uppdrag om uppföljning av IT-användning och IT-kompetens i förskola, skola och vuxenutbildning*, Stockholm: Skolverket

Tredwell M., (2011) Whatever happened? In Wan G. & Gut D. M. (eds.), *Bringing Schools into the 21st Century*. (pp. 7-39) Dordrecht: Springer Netherlands

Venkatesh, V., Morris, M. G., Davis, G. B. and Davis F. D. (2003) User Acceptance of Information Technology: Toward a Unified View. *MIS Quarterly*, 27, pp. 425-478

Venkatesh, V., Thong, J. Y. L. and Xu, X. (2012) Consumer Acceptance and Use of Information Technology: Extending the User Acceptance and Use of Technology. *MIS Quarterly*, 36(1), pp. 157-178

Vestlin L. (red.) (2009). *Från wikis till mattefilmer: om IKT i skolan*. Stockholm: Lärarförbundet

Vidgern R., Avison D., Wood B. and Wood-Harper T. (2002) *Developing Web Information Systems,* Oxfod: Elviser

Vogel, B., Spikol, D., Kurti, A, and Milrad, M. (2010). 'Integrating Mobile, Web and Sensory Technologies to Support Inquiry-Based Science Learning', *Proceedings of the 6th IEEE WMUTE International Conference on Wireless, Mobile and Ubiquitous Technologies in Education* (WMUTE 2010) held in Kaohsiung, Taiwan, April 12-16th, 2010.

Vogel, B (2012) *Architectural Concepts: Implications for the Design and Implementation of Web and Mobile Application to Support Inquiry Learning,* Licentiate, School of Computer Science, Physics and Mathematics, Växjö: Linnaeus University Dissertations

Wan, G. and Gut, D. M. (2011). *Bringing Schools into the 21st Century*. Dordrecht: Springer Netherlands

Widerberg, K. (2006) *Kvalitativ Forskning i praktiken*, Lund: Studentlitteratur

Yau J., Gil, D., Milrad, M., Petersson, O., Salavati, S. and Sollervall, H. (2011). 'Identifying the potential needs to provide mobile context-aware hints to support student's learning'. *Proceedings of The International Conference on Computers in Education*, ICCE 2011 held in Chiang Mai, Thailand, November 28th-December 2nd, 2011

References from Laurillard, Chapter 2.2.1

Dillenbourg, P., Baker, M., Blaye, A., and O'Malley, C. (1996). The evolution of research on collaborative learning. In E. Sspada, & P. Reiman (Eds.), *Learning in humans and machine: Towards an interdisciplinary learning science* (pp. 189–211). Oxford: Elsevier.

Gagné, R. M. (1970/1997). *The Conditions of Learning (3rd ed.).* New York: Holt, Rinehart and Winston.

Merrill, M. D. (1994). *Instructional design theory.* Englewood Cliffs: Educational Technology Publication.

Piaget, J. (1977). Problems of equilibration. In M. H. Appel, & L. S. Goldberg (Eds.), *Topics in cognitive development* (Vol. 1, pp. 3–14). New York: Plenum.

Papert, S. (1991). Situating constructionism. In I. Harel, & S. Papert (Eds.), *Constructionism: research reports and essays, 1985–1990* (pp. 1–11). Norwood: Ablex Publishing Corporation.

Scardamalia, M., and Bereiter, C. (1994). Computer support for knowlege-building communities. *Journal of the Learning Sciences*, 3(3), pp. 265–283.

Scardamalia, M., and Bereiter, C. (2006). Knowledge building: Theory, pedagogy and technology. In K. Sawyer (Ed.), *Cambridge handbook of the learning sciences* (pp. 97–118). Cambridge: Cambridge University Press.

Vygotsky, L. S. (1962). *Thought and language*. Cambridge: MIT.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes.* Cambridge: Harvard University Press.

References from Unified Theory of Acceptance and Use of Technology, Chapter 4.1

Azjen, I. (1991) The Theory of Planned Behavior. *Organizational Behavior and Human Decision Processes,* 50(2) pp. 179-211

Bandura, A. (1986) *Social Foundations of Thought and Action: A cognitive Theory.* Englewood Cliffs: Prentice Hall

Compeau, D.R and Higgins, C.A. (1995) Computer Self-Efficacy: Development of a Measure and Initial Test. *MIS Quarterly*, 19(2) pp. 189-211

Davis, F.D (1989) Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly*, 13(3), pp. 319-339;

Davis, F.D., Bagozzi, R.P., and Warshaw, P.R. (1992) Extrinsic and Intrinsic Motivation to Use computer in the Workplace. *Journal of Applied Social Psychology*, 22(14), pp. 1111-1132

Fishbein, M. and Ajzen, I. (1975) *Belief, Attitude Intentions and Behavior: An Introduction to Theory and Research.* Reading: Addison-Wesley

More, G.C. and Benbasat, I. (1991) Development of an Instrument to Measure the Perceptions of Adopting an Information Technology Innovation. *Information Systems Research,* 2(3), pp. 192-222

More, G.C. and Benbasat, I. (1996) Integrating Diffusions of Innovations and Theory of Reasoned Action Models to Predict Utilization of Information Technology by End-Users. In K. Kautz and J. Pries-Hege (eds.), *Diffusion and Adoption of Information Technology*, (pp. 132-146) London: Chapman and Hall

Rogers, E. (1995) *Diffusion of Innovations.* New York: Free Press

Taylor, S. and Todd, P.A. (1995) Assessing IT Usage: The Role of Prior Experience. *MIS Quarterly,* 19(2), pp. 561-570

Taylor, S. and Todd, P.A. (1995) Understanding Information Technology Usage: A Test of Competing Models. *Informations Systems Research,* 6(4), pp. 144-176

Thompson, R.L., Higgins, C.A., and Howell, J.M (1991) Personal Computing: Toward a Conceptual Model of Utilization. *MIS Quarterly,* 15(1), pp. 124-143

Venkatesh, and Davis, F.D (2000) A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies. *Management Science,* 45(2) pp. 186-204

Appendix A: The eight models of UTAUT

As presented in Chapter 4.1 the UTAUT model by Venkatesh et al. (2003) builds upon eight models which cover different disciplines such as information systems, sociology and psychology:

Theory of Reasoned Action

The Theory of Reasoned Action, TRA, is according to Venkatesh et al. (2003) one of the most influential and fundamental human behavior theories. It has its origins in social psychology (Venkatesh et al., 2003) and states that an individual's intentional behavior is influenced by the individual's attitude toward behavior and the surrounding norm (Oye et al., 2012). This means that an individual's belief influences the attitude they have towards various situations. The attitude of the individual combined with the subjective norms shapes the behavior intentions of that individual (Azjen, 1991). For full reference see Fishbein & Ajzen (1975).

Theory of Planned Behavior

TRA was further refined into the Theory of Planned Behavior, TPB, by adding the construct 'Perceived Behavioral Control'. TPB is a model that has been applied to information systems studies although in general it can be used to study broader acceptance situations (Oye et al., 2012). Taylor and Todd explain the model as applying to situations where individuals have no control over their behavior (Taylor & Todd, 1995). Oye et al. (2012) argue that the users belief of the consequences of the action, the expectations from others as well as the belief about how the user controls or does not control the end result can be understood through this model. For full reference see Azjen (1991), and Taylor and Todd (1995).

Technology Acceptance Model

The Technology Acceptance Model, TAM, is one of the most widely-known and applied models to explain the acceptance and use of Information Technology (IT) and Information Systems (IS) (Kim & Garrison, 2009). TAM builds upon TRA and TBP although its main constructs state that the person's acceptance and use is based on the two beliefs: "Perceived Ease of Use" and "Perceived Usefulness" (Oye et al., 2012). In an extension of TAM, TAM 2 the "Subjective Norm" is added in case of mandatory settings (Venkatesh et al., 2003). For full reference see Davis (1989), and Venkatesh and Davis (2000).

Motivation Model

With the its roots in psychology, Davis et al. (1992) developed the Motivational Model, MM, for the information systems field in order to understand adoption and use of new technology. The MM model is based on motivational theories, explaining an individual's behavior, looking at "Extrinsic-" and "Intrinsic Motivation" (Venkatesh et al. 2003; Davis et al., 1992). For full reference see Davis et al. (1992).

Combined TAM and TPB

This hybrid model, C-TAM and TPB, combines interpretations of TPB with the construct "Perceived Usefulness" from TAM (Venkatesh et al., 2003). For full reference see Taylor and Todd (1995a).

Model of PC Utilization

The model of PC Utilization, MPCU, originates from Trandis' theory of human behavior from 1977 but was adopted by Thompson et al. (1991) for IS context and for predicting PC utilization. The model is well suited to predict individual acceptance and use as it aims to predict usage behavior rather than intensions by for instance looking at "Job-fit" and "Complexity" (Venkatesh et al., 2003). For full reference see Thompson et al. (1991).

Innovation Diffusion Theory

The Innovation Diffusion Theory, IDT, by Rogers (1995) is grounded in sociology and has been used in various innovation studies since the 1960s. More and Benbasat (1991; 1996) adapted the Rogers IDT for the field of information systems by presenting a number of constructs such as "Relative Advantage", "Image Result Demonstrability" and four others to study technology acceptance among individuals (Venkatesh et al., 2003). For full reference see Rogers (1995), More and Benbasat (1991), and More and Benbasat (1996).

Social Cognitive Theory

Social Cognitive Theory, SCT, is one of the most powerful theories of human behavior and was originally developed by Bandura (1986) but was later applied to computer utilization by Compeau and Higgings (1995). The nature of the model enables it to extend the theory to also study use and acceptance of information systems in general. SCT consists of five core constructs looking among others at "Anxiety" and emotional reactions, "Self-efficacy" and "Outcome Expectations" (Venkatesh et al., 2003). For full reference see Bandura (1986), and Compeau and Higgins (1995).

Original references

Azjen, I. (1991) The Theory of Planned Behavior. *Organizational Behavior and Human Decision Processes,* 50(2) pp. 179-211

Bandura, A. (1986) *Social Foundations of Thought and Action: A cognitive Theory.* Englewood Cliffs: Prentice Hall

Compeau, D.R and Higgins, C.A. (1995) Computer Self-Efficacy: Development of a Measure and Initial Test. *MIS Quarterly,* 19(2) pp. 189-211

Davis, F.D (1989) Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly*, 13(3), pp. 319-339;

Davis, F.D., Bagozzi, R.P., and Warshaw, P.R. (1992) Extrinsic and Intrinsic Motivation to Use computer in the Workplace. *Journal of Applied Social Psychology,* 22(14), pp. 1111-1132

Fishbein, M. and Ajzen, I. (1975) *Belief, Attitude Intentions and Behavior: An Introduction to Theory and Research.* Reading: Addison-Wesley

More, G.C. and Benbasat, I. (1991) Development of an Instrument to Measure the Perceptions of Adopting an Information Technology Innovation. *Information Systems Research,* 2(3), pp. 192-222

More, G.C. and Benbasat, I. (1996) Integrating Diffusions of Innovations and Theory of Reasoned Action Models to Predict Utilization of Information Technology by End-Users. In K. Kautz and J. Pries-Hege (eds.), *Diffusion and Adoption of Information Technology,* (pp. 132-146) London: Chapman and Hall

Rogers, E. (1995) *Diffusion of Innovations.* New York: Free Press

Taylor, S. and Todd, P.A. (1995a) Assessing IT Usage: The Role of Prior Experience. *MIS Quarterly,* 19(2), pp. 561-570

Taylor, S. and Todd, P.A. (1995b) Understanding Information Technology Usage: A Test of Competing Models. *Informations Systems Research,* 6(4), pp. 144-176

Thompson, R.L., Higgins, C.A., and Howell, J.M (1991) Personal Computing: Toward a Conceptual Model of Utilization. *MIS Quarterly,* 15(1), pp. 124-143

Venkatesh V., and Davis, F.D (2000) A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies. *Management Science,* 45(2) pp. 186-204

Appendix B: GeM 1 Interview Guides

The interview guides for teachers and students was developed in English, however number of the interview where translated to Swedish interview guides (see B1 and B2) while the rest was translated to Swedish during the interview where the original guide was used.

B1: Teacher Interview 2

- Vad anser du om upplägget för brainstorm mötet i tisdags förra veckan?
- Är det något som du velat göra annorlunda?
    - Arbetssättet:
        - Vara utomhus
        - Arbeta individuellt
        - Mindre grupper
        - Fler/andra verktyg
- Ska forskningsteamet blanda in sig på ett annat sätt?
- Behöver ni mer genomgång av tillgänglig teknik?
- Anser du att ni uppnådde det ni förväntat er av mötet?
- Tycker du att ni är på väg att uppnå det du förväntade dig att uppnå med projektet?
- Är det något du i efterhand kommit på som du skulle vilja komplettera med?
    - Har kompletterat redan?
- Några tankar och funderingar inför framtida möten/workshops?

B1.2: Teacher Interview 2 – English version

- What is your opinion of the brainstorming meeting last Tuesday?
- Was there something you would like to do different?
    - Way of working:
        - Be outdoors
        - Work individually
        - Smaller groups
        - More/other tools
- Should the research team be involved in a different way?
- Do you need more or further information and review of available technology?
- Do you believe you achieved what you expected of the meeting?
- Do you consider being on the right way to achieve what you expected to achieve with this project?
- Is there anything afterwards you have thought about that you would like to complement?
    - Have you already done that?
- Any other ideas or thoughts to have in mind for future meetings and workshops?

B2: Teacher Interview 3 & 4

- Vad tycker du om mötet den 11 mars?
- Vad är din uppfattning av mötet med teknik-killar den 9:e mars?
- Matchade, eller motsvarade tekniken som presenterades med de idéer och förväntningar du hade?
    - Var det något som saknades eller var oklart?
- Vill du ha fler möten med teknik killar?
    - Vad skulle du vilja att vi/de tar upp då?

- Tror du vi uppnått det som förväntas av mötet? Varför eller varför inte?
- Finns det något efter du har tänkt i efterhand du vill tillägga?
- Vad vill ni uppnå med de kommande mötena?
- Vad tror du borde vara nästa steg i projektet och de kommande mötena?
- Några andra idéer och tankar att ha i åtanke för framtida möten och workshops?

B2.2: Teacher Interview 3 & 4 – English version

- What is your opinion of the last meeting on March 11th?
- What is your opinion of the meeting with the technology guys on March 9th?
- Did the technology they presented match/or correspond to the ideas and expectations you had?
    - Was there something missing or unclear?
- Would you like to have more meetings with the technology guys?
- Do you believe we achieved what you expected of the meeting? Why or why not?
- Is there anything afterwards you have thought about that you would like to add?
- What do you wish to achieve with the coming meeting?
- What do you believe should be the next step in the project and the coming meetings?
- Any other ideas or thoughts to have in mind for future meetings and workshops?

B3: Teacher Interview 5

- What is your opinion of the meeting last Monday?
- Do you believe you achieved what you expected of the meeting?
- Did the technology they presented match/or correspond to the ideas and expectations you had?
- What are you're thought regarding the final version of the scenario?
- Is there anything you believe is missing or should be taken under consideration before the trial 13th of May?
- What are you expectations of the trial 13th of May?
    - The students?
    - The technology?
    - The after work with the visualization?

B4: Teacher Interview 6

- What expectations have you had on this project?
    - Where they fulfilled that you expected, different, better worse?
    - Why?
- What were expectations did you have on the trial?
    - Do you think that these technologies and the learning activities are developed more that they would be good teaching tools?
- What did you think of the trial?
    - What problems did you perceive/see as a teacher?
    - How could these problems be avoided?
- In what way could this project be expanded and further developed?
- Have you had any discussion with the students after the trial?
    - Comments?
    - Ideas?

B5: Student Interview A

- Could you start by telling us your name, what school and grade you are in?
- What did you think of today?
- What was the most fun thing?
- What was less fun?
- You where suppose to guess before you calculated things, highs area and so in. Which one did you think was the most correct, your guesses or your calculations, that is before you knew the answer. Did you think you where right or the answers you got with the phone?
- How did you calculate the height or area?
- How did your group work together? Were there any discussions or was there anyone who…
- What did you think about using the technology and the mobile phones?
- If you compare using the mobiles with how you work at school…
- What did you think about the activity you did indoors? Sketch-up and augmented reality?
- Was there something that was less fun or less positive?
- Do you have any ideas on things that could be improved? Things that did not work that well?
- Was that the only thing, you didn't have any problem understanding the activities or what you were suppose to do?
- What did you think of the help videos?
- Do you think the clues helped anything?
- What did you think about the sound? To get a signal when you where at the right place and when something were right or wrong?
- That was my questions unless you have any ideas or suggestions on what could be done differently or better. If there is something we should keep since it was really good or something to remove since it was no good at all?

B6: Student Interview B

- Could you start by telling us your name, what school and grade you are in?
- What did you think of today?
- What was fun?
- Let's think outdoors, indoors. Can you tell about what you thought was good with the outdoors activity, what was not that good and the same for the indoor activity?
- If we think outdoors, you had to figure out how to solve thing. How did you do it, how did you solve the problems?
- What did you think of working with mobile phones?
- Have you done something like this in this in school?
- Would you consider using mobile phones more in school?
- How did your group work together?
- So no one did anything more, you just discussed?
- Which activity was most fun?
- Why?
- What was the most boring thing then? Or was there anything that was boring?
- What did you think of the last thing we did now, Sketch-up and augmented reality?
- What did you think of the signals? Did the come at the right place, were they sufficient…
- Do you have any other ideas or suggestions on what could be improved?
- That was my questions unless you have any ideas or suggestions on what could be done differently or better.

Appendix C: GeM 1 Survey and Observation Guides

The surveys handed out to the participants in the GeM 1 trial was developed in English (see C1.2, C2.2 and C3:2) and translated to Swedish for the participants. The surveys handed out to the participants are Appendix C1, C2 and C3. The observation guide was developed and used in English.

C1: Survey 1

Ditt namn: _____ Ålder: _____ Kön: _____

Räkna upp några ord som du tycker hör ihop med geometri?

_____

_____

Hur mycket tycker du att du kan om geometri?

☐ Lite ☐ Ganska Lite ☐ Medel ☐ Ganska Mycket ☐ Mycket

Hur många mobiltelefoner har du haft? _____

Har du haft en Nokia-mobil någon gång?

☐ Ja ☐ Nej

Har du en Nokia-mobil nu?

☐ Ja ☐ Nej

Har du tidigare gjort något skolarbete utomhus?

_____

_____

Har du använt mobiltelefoner för skolarbete?

_____

_____

Hur skulle du göra om du skulle göra en bra uppskattning av höjden av en byggnad?

_____

_____

Hur skulle du göra för att räkna ut diametern av en rund sjö eller en större cirkel?

_____

_____

Kan du ge 3 förslag på vart du skulle kunna ha användning av dina geometrikunskaper (utanför skolan)?

1:_____

2:_____

3:_____

Har du designat/skapat något i ett grafiskt 3D program tidigare? (Om ja, berätta kort)

_____

_____

C1.2: Survey 1 – English Version

- …
- How would you guess a height of a building?
- How would you figure out a diameter of a round lake or large circle?
- What would you use geometry for outside of school (Can you list 3 ideas)?
- Have you ever designed things in a 3D graphics program before? (if so describe briefly)

C2: Survey 2

Ditt namn: _____

Tyckte du om att arbeta med geometriuppgifterna utomhus?

_____

_____

Hur väl överensstämde dina gissningar av höjden av slottet och diametern av Amfium jämfört med de beräknade/uppmätta värdena?

_____

_____

Hur löste ni era uppgifter? Deltog alla i gruppen eller var det någon som gjorde det mesta?

_____

_____

Kan du ge något förslag på ett annat sätt att räkna ut höjden eller diametern på större föremål?

_____

_____

Vad tyckte du bäst om av utomhusaktiviteten och varför?

_____

_____

Vad tyckte du minst om av utomhusaktiviteten och varför?

_____

_____

C2.2: Survey 2 – English version

- Did you like doing geometry outside?
- How did your guesses about the height of the castle and diameter of amphium compare to your calculations?
- How did your group solve the problems, together or did one person do all the work?
- Can you think of other ways to calculate the height or diameter of big things? (Describe one if you can)
- What did you like most about the outdoor activity and why?
- What was the worst thing about the outdoor activity and why?

C3: Survey 3

Ditt namn: _____

Vad inspirerade dig till att välja just den designen när du ritade din byggnad?

_____

_____

_____

Kan du komma på några andra områden utanför skolan där geometri används? (Ge några exempel, som t.ex. arkitektur)

_____

_____

Vad tyckte du bäst om av inomhusaktiviteten och varför?

_____

_____

Vad tyckte du sämst om av inomhusaktiviteten och varför?

_____

_____

Vilka nya ord som har med geometri att göra har du lärt dig under dagen?

_____

_____

C3.2: Survey 3 – English version

- What was your inspiration for your building design?
- Can you think of some other uses of geometry outside of school? (Give a few examples, like architecture)
- What did you like most about the indoor activity and why?
- What was the worst thing about the indoor activity and why?
- What words/concepts related to gemotry have you learned during the day?

C4: Observation guide

Observers Name: **Date:** **Group nr:**	
Time: Task Area: Task Height: Task Indoor:	**Facts** Nr students: Age range: Genders:
Group Dynamics/ Content/Learning - Engagement & Motivation - How did they work as a group? Discussions Dominant Students Frustration - Guesses & Calculations - Problem Interpretation - Problem Solution - Heuristics - Describe your opinion	
Mobile Technology - Difficulties understanding the tasks - Problems - Crashes - How did they use the help video? - Grasp of measurement tools on the phone?	

Indoor Technology - Individual work effort - Skill in using Sketchup - Augmented Reality Visualization - Group discussion	
Comments	

Appendix D: GeM 3 Interview Guides

Uppgiften:

1. Berätta vad ni har gjort?
    a. Hur gjorde ni och varför?
    Inomhus och utomhus

2. Vilka förväntningar hade ni? Vilka tankar hade ni kring aktiviteten innan ni utförde den?
    a. Uppgiften
    b. Tekniken/Mobilen
    c. Uppfylldes förväntningarna, tankarna?

3. Hur var aktiviteten och tekniken?
    a. Skulle ni klara av aktiviteten själva bara tillsammans med er lärare?
        i. Om nej, varför?
        ii. Tror ni att detta skulle fungera med hela er klass?
    b. Skulle ni vilka göra flera liknande aktiviteter?

4. På en skala från 1-5 (1, inte alls och 5, väldigt mycket), hur mycket tyckte ni om/uppskattade ni att utföra denna aktivitet?
    a. Vad och Varför?

5. Vad tror ni syftet med uppgiften och aktiviteten har varit?
    a. Inomhus
    b. Utomhus

6. Vad har ni lärt er?
    a. Tror ni att man får bättre förståelse för liknande uppgifter om man använder sig utav teknik (mobiltelefoner, datorer, digitala pennor) och att få vara utomhus?
        i. På vilket sätt och varför?

7. Använde ni er utav det ni lärde er förra gången?
    a. Vad lärde ni er förra gången?
    b. Hur använde ni den kunskapen för inomhus aktiviteten denna gången?

8. Vilka metoder använde du när du löste problemet?

9. Använde du alla metoder som du diskuterade tillsammans med dina klasskamrater igår?
    a. Om ja, tycker/tror du att diskussionen tillförde någon hjälp för att lösa aktiviteten?
    b. Om nej, varför använde du inte metoderna? Glömde du bort dem eller fanns det andra anledningar.

10. Tror ni att ni kommer kunna använda er utav det ni har lärt er under dessa aktiviteter?
    a. Vad? Hur?

11. Hur många personer var det i din grupp? Tror du att det hade varit bättre om det var mer/mindre personer i din grupp?

12. Hur tycker du att grupperna skulle fördelats/skapats?
    b. Bestämmas av läraren?
    c. Studenterna väljer själva även om någon student ev. hamnar utanför?
    d. Baserat på din kunskap och färdigheter inom matematik för att få liknande gruppmedlemmar?
    e. Baserat på förmågan att kommunicera med varandra så att gruppen kan samarbeta tillfredställande?

Uppgiften och ledtrådar

13. Skulle du velat ha hjälp av ledtrådar för att lösa uppgiften under aktiviteten? -Ja -Nej
    a. Om så, var under aktiviteten – början/mitten/slutet/hela?
    b. Om så, under vilka delar av aktiviteten – det enkla/mellan svåra/väldigt svåra?
    c. Om så, skulle ledtrådarna ges efter dit första/andra/tredje/fjärde/etc. försök för att hitta de 10 punkterna i aktiviteten?
    d. Om så, skulle ledtrådarna visats efter varje felaktigt försök?
       -Ja -Nej
    e. Skulle du fått ledtrådarna även om du inte hade några felaktiga försökt?
       -Ja -Nej *(var säker på att de har förstått hur de fick rätt svar och att svaret de fått inte varit slumpmässigt)*
    f. Om så, skulle du få ledtrådarna om du spenderat lång tid på att försöka lösa uppgiften, genom att hitta de olika punkterna?

14. Vilken typ av ledtråd skulle du velat ha? *(Om möjligt be dem ge anledningar till var och en av alternativen nedan)*
    a. Ljud/Bilder/Video/ alla
        i. Varför?
    b. Dynamiska *(sådana som ger ledtrådar baserat på det avståndet som du arbetar med)* eller statiska *(t.ex. inte baserat på avståndet men generella exempel så som hur du räknar ut avstånd t.ex.)*?
    c. Interaktiva/inte interaktiva *(interaktiva är sådana som du kan påverka resultatet på genom att ange värden (t.ex. siffror) eller annat liknande)*?
    d. Skulle du velat ha ledtrådar som visas när du efterfrågar dem?
    e. Skulle du velat ha ledtrådar som visas baserat på vad du matar in i apparaten ?
    f. Skulle du vilja att ledtråden visas automatiskt *(t.ex. den skulle veta om du ev. skulle behöva ledtrådar)* och inte baserat på när du begär avståndet)
    g. Skulle du vilja ha anpassningsbara/icke anpassningsbara frågor *(t.ex. om apparaten vet hur du föredrar att lösa uppgiften (som aktivt/passivt) och utifrån det föreslå ledtrådar till dig med hänsyn till hur du skulle föredra att lära dig)*?
        ii. Baserat på din normala matematiska prestation i skolan
        iii. Baserat på din prestation under aktiviteten
    h. Om ledtrådarna ska vara video, ska de vara korta och enkla, eller långa och detaljerade, och varför?

Specifika CA frågor för denna matematik aktiviteten

15. Skulle du vilja ha ledtrådar för följande:
    a. För att räkna ut likbenta trianglar
    b. För att räkna ut andra typer av trianglar så som (liksidiga)?
    c. När du är för långt bort eller för nära en specifik punkt?
    d. När du är på väg mot fel riktning?
    e. För att säga att du borde gå parallellt för att nå till slutpunkten?
    f. Kanske visa några video ledtrådar till studenterna (bilder på papper eller video på en mobil) för att fråga dem om de ledtrådarna skulle vara användbara för dem och varför?

Tekniken:

16. Har ni arbetat med teknik tidigare i skolan?
    a. Vad? Hur?

17. Skulle ni vilja använda teknik i skolan?
    a. Varför? På vilket sätt?

18. Vad skulle du vilja att tekniken skulle kunna göra?
    a. Varför?

19. Tror du det (teknik etc.) underlättar att förstå lektionerna? *(Question to students but mainly teachers)*

20. Skulle typen av teknik spela någon roll och göra skillnad?
    a. Smartphone som den ni hade nu eller bärbar datorer?

   b. Typ av dator eller typ av telefon?
   c. 'Gammal' vs. ny?

21. Hur fungerade GPS:n?

22. Vad tyckte ni om att använda GPS (gemensam/delade GPS värden) för att räkna ut avstånd?
   a. Hur skulle man kunna göra samma sak på ett annorlunda sätt?
      iv. Vad borde mobilen kunna göra?
      v. Det som var bra? / Det som saknades?

23. Tycker du det är användbart att använda mobil telefonen på detta sättet?
   a. På vilket sätt? Varför?

24. Under aktivitetens gång använde du flera apparater för att räkna ut avstånden. Detta sker genom att informationen som finns på de olika telefonerna delas mellan de olika apparaterna.
   b. Vad tycker du/ anser du om att få tillgång till information från på en kollega/kamrater telefon för att kunna samarbeta?

25. Om du fick vara med och bestämma vad för teknik som skulle finnas för att lösa denna aktivitet, vilka funktioner (saker) anser du att den borde ha? Vad tycker du är viktigt att ha med (funktioner, apparat etc.)?

Tack!

Appendix E: LETS GO Data Collection Guides School Trials

The teachers interviews have been translated to Swedish on the interview session and the English guide have been used.

E1: Teacher Interviews

1. Please state your name, school you work at (role within the project). In what grade do you teach? How many year have you been teaching and in what subjects?
2. What is your experience with technology in education? What is your opinion of using modern technology in education?
3. What expectations do you have of this project? What do you wish to achieve? Why did you choose to be involved in the project?
4. What is your opinion of the brainstorming meetings in the end of November? Was there something you would like to do different in the group work conducted so far?
5. How would you like to work with the researchers and developers in the future?
6. Is there anything afterwards you have thought about that you would like to add?
7. Any other ideas or thoughts to have in mind for future meetings and workshops?
8. How often do you apply inquiry-learning practices in your teaching?
9. How do you think inquiry based learning should be supported by new technologies?

E2: Student Interviews School B

- Vad heter du/hur gammal är du?
- Vad tyckte du om detta projektet?
- Har du jobbat på liknande sätt med mobiler och sensorer tidigare?
- Var det svårt?
    - Vad?
- Vad skulle du tycka om att jobba på liknande sätt fler gånger?
    - Andra ämnen?
- Vad var bra?
- Vad var mindre bra?
- Hur tror du att detta projektet skulle kunna utvecklas?
- Hur fungerade samarbetet? Fick alla prova på arbeta med mobilen /sensorerna?
- tycker du att du lärt dig något nytt?
    - Vad?
- Vad anser du om mobilen
- pasco
- visulaseringen
- vad kan förbättras
- annat

Appendix F: LETS GO Data Collection Guides Prospective Teachers' Trial

The surveys handed out to the participants in the prospective teacher trial of the LETS GO was developed in English (see F1.2 and F2:2) and translated to Swedish for the participants. The surveys handed out to the participants are Appendix F1 and F2.

F1: Pre-trial Survey

Let's Go Enkät 1

Denna enkät syftar till att skapa en förståelse för vilken uppfattning lärarstudenter dvs. blivande lärare har av teknik, dels som privatpersoner men även inom den profession de kommer att arbeta i. Denna enkät är den första av två och består av 10 frågor.

Tack!

Initialer: _____

Ålder: _____

Kön: ❑ Man ❑ Kvinna

1. Jag använder mig frekvent av teknik (datorer, mobiltelefoner, internet osv.) i mitt vardagliga liv.

○	○	○	○	○
Håller inte alls med	Håller delvis inte med	Varken eller	Håller delvis med	Håller med fullständigt

2. Hur ofta använder du sociala medier så som Facebook, Twitter, MySpace, bloggar, wikis osv. i ditt vardagliga liv utanför arbete/skola?

○	○	○	○	○
Inte alls	Månadsvis	Veckovis	En gång om dagen	Flera gånger om dagen

3. Som student i min utbildning har jag frekvent varit i kontakt med och använt modern teknik (interaktiva tavlor, mobil telefoner, sensorer, digitala pennor)?

○	○	○	○	○
Håller inte alls med	Håller delvis inte med	Varken eller	Håller delvis med	Håller med fullständigt

4. Jag anser att modern teknik (interaktiva tavlor, mobiltelefoner, sensorer, digitala pennor osv.) var använt på ett optimalt sätt under min studietid.

○	○	○	○	○
Håller inte alls med	Håller delvis inte med	Varken eller	Håller delvis med	Håller med fullständigt

5. Vad är din uppfattning om teknik inom undervisning och skolan/ Vad anser du om teknik som ett hjälpmedel inom utbildning?

○	○	○	○	○
Negativt	Delvis negativt	Ingen åsikt	Delvis positivt	Positivt

6: Vilken roll anser du teknik ska ha inom utbildning och lärande?

○	○	○	○	○
Bör inte ha någon speciell roll	Bör vara en egen/en del av/integrerad del av ett ämne	Ingen åsikt	Fungera som en hjälpmedel/stöd i undervisning och lärarprocessen	Annat

7: Anser du att teknik kan påverka lärande miljön?

○	○	○	○	○
Håller inte alls med	Håller delvis inte med	Varken eller	Håller delvis med	Håller med fullständigt

7a Om modern teknik implementerades i den dagliga utbildning och lärande miljön, vilken påverkan tror du det skulle ha?

○	○	○	○	○
Negativt	Delvis negativt	Ingen åsikt	Delvis positivt	Positivt

8. Jag kan tänka mig som lärare använda tekning så som mobiltelefoner, interaktiva tavlor, sensorer, digitala pennor etc. i min undervisning.

○	○	○	○	○
Håller inte alls med	Håller delvis inte med	Varken eller	Håller delvis med	Håller med fullständigt

9. Vilka förväntningar har du på denna aktivitet?

○	○	○	○	○
Negativt	Delvis negativt	Ingen åsikt	Delvis positivt	Positivt

10. Övriga kommentarer?

_____

_____

F1.1: Pre-trial Survey

Let's Go Teacher Student Pre-Survey

This survey aims to gain an understanding on how teacher students i.e. becoming teachers perceive technology both in their private life but also as the profession they will be working in. This survey is the first of second and consists of 10 questions.

Thank you!

Initials: _____
Age: _____
Gender: ❑ Male ❑ Female

Pre-survey
Background

1. I frequently use technology (computers, mobile phones, internet etc.) in my everyday life.

○	○	○	○	○
Strongly Disagree	Disagree	Indifferent	Agree	Strongly Agree

2. How often do you use social media, e.g. Facebook, Twitter, MySpace, blogs, wikis, etc. in your life everyday outside school/work?

○	○	○	○	○
Nothing	Monthly	Weekly	Once a day	Several time a day

3. I have frequently come across and used modern technology (interactive whiteboards, mobile phones, sensors, digital pens etc.) as a student in my own education.

○	○	○	○	○
Strongly Disagree	Disagree	Indifferent	Agree	Strongly Agree

4. I believe modern technology (interactive whiteboards, mobile phones, sensors, digital pens etc.) was used in a optimal way during my studies.

○	○	○	○	○
Strongly Disagree	Disagree	Indifferent	Agree	Strongly Agree

5. What is your standpoint in technology in education and schools? / What do you think of technology as a teaching and learning tool in education?

○	○	○	○	○
Negative	Somehow negative	Indifferent	Somehow positive	Positive

6: What role do you think technology should have in educational settings?

○	○	○	○	○
Should not have any particular role	Should be a own/part of/ integrated with some other subject	Indifferent	Function as a supporting tool in the teaching and learning process	Other

7: Do you believe technology could have an impact on the learning settings?

○	○	○	○	○
Strongly Disagree	Disagree	Indifferent	Agree	Strongly Agree

7a If modern technology where to be implemented in everyday teaching and learning practice, what type of impact would you believe it to have?

○	○	○	○	○
Negative	Somehow negative	Indifferent	Somehow positive	Positive

8. I would consider using technology such as mobile phones, interactive whiteboards, sensors, digital pens etc. as a teacher in my teaching.

○	○	○	○	○
Strongly Disagree	Disagree	Indifferent	Agree	Strongly Agree

9. What expectations do you have on this activity?

○	○	○	○	○
Negative	Somehow negative	Indifferent	Somehow positive	Positive

F2: Post-trial Survey

Let's Go Enkät 2

Detta är den andra enkäten som syftar till att skapa en förståelse för vilken uppfattning lärarstudenter dvs. blivande lärare har av teknik dels som privatpersoner men även inom den profession de kommer att arbeta i. Denna enkät består av 8 frågor där några av frågorna kan kännas bekant sedan tidigare.

Initialer: _____
Ålder: _____
Kön: ❑ Man ❑ Kvinna

1: De förväntningar jag hade på aktiviteten har uppfyllts.

○	○	○	○	○
Håller inte alls med	Håller delvis inte med	Varken eller	Håller delvis med	Håller med fullständigt

2. Efter att ha utfört denna aktivitet, vad anser du om teknik som ett hjälpmedel inom utbildning?

○	○	○	○	○
Negativt	Delvis negativt	Ingen åsikt	Delvis positivt	Positivt

3: Efter att ha utfört denna aktivitet, anser du att teknik kan påverka lärande miljön?

○	○	○	○	○
Negativt	Delvis negativt	Ingen åsikt	Delvis positivt	Positivt

4. Efter att ha utfört denna aktivitet, kan jag tänka mig som lärare använda tekning så som mobiltelefoner, interaktiva tavlor, sensorer, digitala pennor etc. i min undervisning.

○	○	○	○	○
Håller inte alls med	Håller delvis inte med	Varken eller	Håller delvis med	Håller med fullständigt

5: Hur uppfattar/anser du att arbeta/denna uppgift jämfört med traditionell sätt att utföra liknande uppgift.?

○	○	○	○	○
Negativt	Delvis negativt	Ingen åsikt	Delvis positivt	Positivt

6: Anser du att detta arbetssätt (med mobiltelefoner, sensorer och datorer) är svårare och mer komplicerat i förhållande till mer ”traditionella” arbetssätt.

○	○	○	○	○
Håller inte alls med	Håller delvis inte med	Varken eller	Håller delvis med	Håller med fullständigt

7: Anser du att detta arbetssätt och lära kan fungera i skolan?

○	○	○	○	○
Håller inte alls med	Håller delvis inte med	Varken eller	Håller delvis med	Håller med fullständigt

8: Hur tror du eleverna skulle anse om detta sättet att lära sig?

○	○	○	○	○
Negativt	Delvis negativt	Ingen skillnad	Delvis positivt	Positivt

9. Övriga kommentarer?

_____

_____

F2.2: Post-trial Survey – English version

Let’s Go Teacher Student Post-Survey

This is the second survey which aims to gain an understanding on how teacher students i.e. becoming teachers perceive technology both in their private life but also as the profession they will be working in. This survey consists of 7 questions where as you might recognize some of the questions from previous.

Initials: _____
Age: _____
Gender: ❑ Male ❑ Female

1: My expectation on this activity was fulfilled.

○	○	○	○	○
Strongly Disagree	Disagree	Indifferent	Agree	Strongly Agree

2. After doing this activity, what is your standpoint in technology in education and schools? / After doing this activity, what do you think of technology as a teaching and learning tool in education?

○	○	○	○	○
Negative	Somehow negative	Indifferent	Somehow positive	Positive

3: After doing this activity, do you believe technology could have an impact on the learning settings?

○	○	○	○	○
Negative	Somehow negative	Indifferent	Somehow positive	Positive

4. After doing this activity, I would consider using technology such as mobile phones, interactive whiteboards, sensors, digital pens etc. as a teacher in my teaching.

○	○	○	○	○

Strongly Disagree	Disagree	Indifferent	Agree	Strongly Agree

5: How do you perceive this activity/way of working compared to traditional way of conducting a similar task?

○	○	○	○	○
Negative	Somehow negative	Indifferent	Somehow positive	Positive

6: Do you think this way of working (learning) might work at a school?

○	○	○	○	○
Strongly Disagree	Disagree	Indifferent	Agree	Strongly Agree

7: How do you think the pupils will perceive this way of learning?

○	○	○	○	○
Negative	Somehow negative	Won't make any difference	Somehow positive	Positive

F3: Interview Prospective Teachers:

The interview conducted with the prospective teachers where mainly unstructured and was based on the outcome of the surveys.

Appendix G: Collboard Data Collection Guides

G1: Survey Students

My age is ____ years old and

I am

○ Female ○ Male

1. How interested are you in math?

○ I don't like math at all ○ Not interested ○ Indifferent ○ Interested ○ It's my favorite subject

2. Did you enjoy being part of the experience with Collboard?

○ I didn't enjoy it at all ○ Not really ○ Indifferent ○ Yes ○ Very much

3. "Writing on paper with the digital pen felt just like writing on paper with a regular ball pen." – Do you agree?

○ Strongly Disagree ○ Disagree ○ Indifferent ○ Agree ○ Strongly Agree

4. "Not being able to erase from the paper when using the digital pen is very frustrating." –Do you agree?

○ Strongly Disagree ○ Disagree ○ Indifferent ○ Agree ○ Strongly Agree

5. I prefer using a graphite pencil rather than a ball pen to solve math problems.

○ Strongly Disagree ○ Disagree ○ Indifferent ○ Agree ○ Strongly Agree

6. I am satisfied about the quality with which my answers written on paper later appeared on the interactive whiteboard.

○ Strongly Disagree ○ Disagree ○ Indifferent ○ Agree ○ Strongly Agree

7. The answers on the interactive whiteboard were hard to read.

○ Strongly Disagree ○ Disagree ○ Indifferent ○ Agree ○ Strongly Agree

8. I felt nervous when I was called to the front.

Strongly Disagree	Disagree	Indifferent	Agree	Strongly Agree
○	○	○	○	○

9. I don't like being called to the front in regular math lessons.

Strongly Disagree	Disagree	Indifferent	Agree	Strongly Agree
○	○	○	○	○

10. I prefer being called to the front in the Collboard activity than in a regular math lesson.

Strongly Disagree	Disagree	Indifferent	Agree	Strongly Agree
○	○	○	○	○

11. In the discussions I could talk to the teacher *more often* that in a regular math lesson.

Strongly Disagree	Disagree	Indifferent	Agree	Strongly Agree
○	○	○	○	○

12. In the discussions I could communicate with the teacher *better* than in a regular math lesson.

Strongly Disagree	Disagree	Indifferent	Agree	Strongly Agree
○	○	○	○	○

13. In the discussions I could talk to my classmates *more* often than I do in a regular math lesson.

Strongly Disagree	Disagree	Indifferent	Agree	Strongly Agree
○	○	○	○	○

14. In the discussions it was difficult for me to follow what the teacher and my classmates were saying.

Strongly Disagree	Disagree	Indifferent	Agree	Strongly Agree
○	○	○	○	○

15. After the discussions I felt that I could understand the final answer and solve the problem correctly again by myself if I was required so.

Strongly Disagree	Disagree	Indifferent	Agree	Strongly Agree
○	○	○	○	○

16. The selection of math problems was too easy for me.

Strongly Disagree	Disagree	Indifferent	Agree	Strongly Agree
○	○	○	○	○

17. The discussions using the interactive whiteboard were very important for me to understand how to solve the problems.

○	○	○	○	○
Strongly Disagree	Disagree	Indifferent	Agree	Strongly Agree

18. Were you ever called to the front to work on the interactive whiteboard in a discussion?

○	○
Yes	No

19. ***(Only if you answered Yes on Q18)*** The basic tools in the interactive whiteboard, such as "Paint", "Select", "Erase", "Undo" and "Redo" were very easy to learn and use.

○	○	○	○	○
Strongly Disagree	Disagree	Indifferent	Agree	Strongly Agree

20. ***(Only if you answered Yes on Q18)*** The "Select" and "Drag and drop" tools in the interactive whiteboard were very easy to learn and use.

○	○	○	○	○
Strongly Disagree	Disagree	Indifferent	Agree	Strongly Agree

21. I would like the teacher to continue using Collboard in the future.

○	○	○	○	○
Strongly Disagree	Disagree	Indifferent	Agree	Strongly Agree

What do you think is the best thing about the Collboard activity?

What do you think is the worst thing about the Collboard activity?

Can you think of anything you would like to be different the next time you are involved in a Collboard activity?

G2: Interview Teachers:

1. Did you feel comfortable using the interactive whiteboard tool with the Collboard software?
    a. Visualization of answers.
    b. Switching between answers.
    c. Writing the collective answer.
    d. Performing basic user interface operations:
        i. Clicking.
        ii. Scrolling.
        iii. Drag & drop.
        iv. Write.
        v. Erase.
        vi. Undo/Redo
2. What expectations did you have before using Collboard? Have your prior expectations been fulfilled after the trial?
3. What would you say are the benefits of using Collboard?
4. What are the disadvantages or inconveniences of using Collboard?
    a. What could be improved, and how?
5. Do you think Collboard facilitates fostering active learning, participation and collaboration in the classroom?
    a. Are you satisfied with the level of student participation that is achieved using Collboard?
6. Do you think Collboard could be integrated in every day teaching?
    a. Is preparing a lesson that involves Collboard more difficult or more work than preparing a regular lesson?
    b. Do you think Collboard could be generally accepted in the school, even by teachers that aren't too enthusiastic about adopting technology in the classroom?
7. How do you perceive the students' attitude towards a participatory activity in the classroom such as Collboard?
8. How do you think Collboard would scale to be usable with a larger classgroup?
    a. In its current status, how many students do you think you could handle with Collboard in order to achieve a satisfactory result?
9. What other subjects do you think Collboard could be beneficial for?
10. Do you think Collboard could be integrated with other technological tools currently in use in you school (for instance, Moodle)

Appendix H: GeM UTAUT data categorization

Table H. 1. GeM Constructs

Performance Expectancy	Effort Expectancy	Social Influences	Facilitating Conditions	Voluntariness of Use	Hedonic Motivation	Experience / Habit
To be outdoors and actually experience what it is you are doing. To do tasks in a more practical matter and get a better comprehension, so it isn't just pure factual knowledge but also understanding and what comes with that.	The technology is difficult to understand for us pedagogues'	The kids will appreciate it		If a product is not working for half of the groups one will stop to use it. Driven and engaged teachers will find a way to solve it but for it to become commonly used it is very important that it works		
To be active	The technology was not difficult to understand.	The students want this challenge		Reliability and smoothness of the technology for the teachers		
To have good discussions within the group is what we want to achieve. Good discussions leads to new knowledge, that you explain something and get something explained to you		important that schools modernize their way of educating		Smoothness of the use is important if one is going to use it for real		One will learn how to use the technology gradually and then these discussions will be easer to achieve and the focus will be on what one intend to and not on learning to use the technology
these kind of activities will enhance their understanding and learning		The students will be motivated and thinks it is exciting		It has to be easy otherwise the teachers won't want use it		
				Has to be as user friendly as possible so I as a teacher can borrow the equipment and use it		

Appendix I: LETS GO UTAUT data categorization

Table I. 1. LETS GO Constructs

Performance Expectancy	Effort Expectancy	Social Influences	Facilitating Conditions	Voluntariness of Use	Hedonic Motivation	Experience / Habit
With the older kids maybe one can do things	Mobile phones was the hard part	The students would like this	Good to have a practicing lesson	It is not about whether we want to use it or not but the evolution is going that way and we have to learn		Easy for our generation to understand
In physical education it is pretty hard I guess	Understand the phone	Easy for our generation to understand and easy to learn out	Schools may have the technology… but they don't know how it works	I must be very comfortable with things before I use it		Computers and mobiles were difficult to use since we have not had it much in our education
It is great (when presented how technology could be used)	The instrument was the hardest part	It is so common	It is expensive and they prioritize other things	Someday I must do it		Unfamiliarity to use the computer
Children use different senses; some more here and some more with their eyes	The whole thing was tricky	To keep children interested it is important to keep up with their interests, to give the education they respond to	Not enough education in the teacher education program on how to use technology in schools – do not think it will be provided any either	I don't think we can chose in the future		
Need both traditional and technology – need, need to combine them both. Take good parts of both	Easy for our generation to understand and easy to learn out	Students today are more familiar with computers	Would like to have more education	We are forced to learn this with computers		
It is more stimulating to work this way	Easy to bring with you outdoors	Evolution is going that way	Practice and question session in the classroom before going out was good	I think it is interesting and I am very open for the new things and I can learn something of that		
If I am going to replace my board with one of those it has to	Computers and mobiles were difficult to use since we have not had	It is going towards this form of education	The manual enabled to sit at home and look at it to prepare	If I am going to replace my board with one of those it has to weigh much		

weigh much heavier, it must be so much more	it much in our education			heavier, it must be so much more
It simplifies when you get into it	If we had more time we would have learned it – it was difficult because the time was short – we would have been very good at it if we had more time	It becomes more natural for children	Computers and mobiles were difficult to use since we have not had it much in our education	The older generation will first say 'I don't have a choice, I have to'
Use the same template for several students	Unfamiliarity to use the computer	Children would think this was exciting, to do this, to work this way	we would have been very good at it if we had more time	Don't have a choice
	I must be very comfortable with things before I use it	They think it is fun,	if we had worked one more month with this we would have been really good at it I think	
	It has to be practical		We have IWB's in almost all classrooms but not everyone can teach it	
	It should not take too much time to prepare – must be easy to perform		Computers are provided by the school but not working hours, I have to put from my own time	
			Proper education for them who are insecure	
			The time given is not enough	
			Education and knowledge is given from the schools	

Appendix J: Collboard UTAUT data categorization

Table J.1. Collboard Constructs

Performance Expectancy	Effort Expectancy	Social Influences	Facilitating Conditions	Voluntariness of Use	Hedonic Motivation	Experience / Habit	Other
Good from teachers perspective since one can help students create the ultimate solution together	Easy to use		Right training and education	With the right training and showing that it is simple to use most people would work with it			There are other factors beside the technology that matters in use of technology in larger classes, such as students as such
It is okay if one have not reached the final but still can contribute	Difficult with full class to get all students active […] if a full class consist of 28 students		In order to be comfortable with the technology there is need to be educated in it	All new ways of learning with technology is very positive			
Get the oral activity started which can be difficult specially with the more silent students who normally don't like to speak	It could take some time before getting use to the technical part and then one have to…or not really, finding tasks which needs discussion can occur in normal settings as well		Number of students aren't the issues, the time for each lesson is the issue				
Definitely useful	Relatively user friendly						
One way of fostering active learning, participation and collaboration	Blue colored group: teacher had much more charge of the IWB during the first sessions but eased up and gave much more space to the						

	students by the end of the trial	
One way of increasing interactivity among both teacher-student and student-student	Some problems with the pens and some software stuff	
The system integrating with other systems would increase collaboration between teachers as well as students and contribute to shared learning	Absolutely not difficult to use…'just put the problem in the software and you are ready to go'	
A way to start a discussion	Time issue is a problem… takes quite a lot of time to do the whole process	
A good way for students to feel that they have contributed	Absolutely easy to use	
Forces students to collaborate, create discussions. Forces them to have a discussion on different methods for solving the task and the main thing is to have those discussions. Students discussing is the best way they learn	Black colored group: teacher encourage the students to use the IWB and be more active early in the trial	

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Licentiate Theses

1. **Johansson, Niklas E. (2004)** *Self-Service Recovery - Towards a Framework for Studying Service Recovery in a Self-Service Technology Context from a Management and IT Perspective,* Licentiate Thesis KUS 2004:3, Karlstad University.

2. **Ekman, Peter (2004)** *Affärssystem & Affärsrelationer - En fallstudie av en leverantörs användning av affärssystem i interaktionen med sina kunder,* Licentiate Thesis No.25, Mälardalens universitet.

3. **Wrenne, Anders (2004).** *Tjänsteplattformar - vid utveckling av mobila tjänster inom telekommunikation,* Licentiatavhandling, KUS 2004:4, Karlstads universitet, Centrum för tjänsteforskning.

4. **Wismén, May (2004).** *Kunskapsprocesser inom hälso- och sjukvård - en studie av kunskapsintegrering mellan laboratorium och dess kunder*, Licentiatavhandling, KUS 2004:10, Karlstads universitet.

5. **Stoltz, Charlotte (2004).** *Calling for Call Centres - A Study of Call Centre Locations in a Swedish Rural Region,* Licentiate Thesis, No. 1084, IDA-EIS, Linköping University, Institute of Technology.

6. **Abelli, Björn (2004).** *Theatre Production - A System Development Process,* Licentiate thesis No. 30, Mälardalen University.

7. **Maaninen-Olsson, Eva (2004).** *Det gränslösa projektet - En studie om förmedling och skapande av kunskap i tid och rum,* Licentiatavhandling nr. 41, Företagsekonomiska institutionen, Uppsala Universitet,.

8. **Sällberg, Henrik (2004).** *On the value of customer loyalty programs – a study of point programs and switching costs,* Licentiate Thesis, No. 1116, IDA-EIS, Linköping University, Institute of Technology.

9. **Stockhult, Helén (2005).** *Medarbetaransvar - ett sätt att visa värderingar: En konceptualisering av medarbetarnas ansvar och ansvarstagande i callcenter,* Licentiatavhandling nr. 1, Örebro universitet, Institutionen för ekonomi, statistik och informatik.

10. **Vascós Palacios, Fidel (2005).** *On the information exchange between physicians and social insurance officers in the sick leave process: An Activity Theoretical perspective,* Licentiate Thesis, No. 1165, IDA-EIS, Linköping University, Institute of Technology.

11. **Keller, Christina (2005).** *Virtual Learning Environments in higher education. A study of students' acceptance of educational technology*, Licentiate Thesis, No. 1167, IDA-EIS, Linköping University, Institute of Technology.

12. **Ahlström, Petter (2005),** *Affärsstrategier för seniorbostadsmarknaden,* Licentiatavhandling, No. 1172, IDA-EIS, Linköpings universitet, Tekniska Högskolan.

13. **Dahlin, Peter (2005).** *Structural Change of Business Networks – Developing a Structuration Technique,* Licentiate Thesis No. 49, Mälardalen University.

14. **Granebring, Annika (2005).** *ERP Migration Structure – an Innovation Process Perspective,* Licentiate Thesis No. 50, Mälardalen University.

15. **Cöster, Mathias (2005).** *Beyond IT and Productivity – How Digitization Transformed the Graphic Industry,* Licentiate Thesis, No. 1183, IDA-EIS, Linköping University, Institute of Technology.

16. **Horzella, Åsa (2005).** *Beyond IT and Productivity – Effects of Digitized Information Flows in Grocery Distribution,* Licentiate Thesis, No. 1184, IDA-EIS, Linköping University, Institute of Technology.

17. **Kollberg, Maria (2005).** *Beyond IT and Productivity – Effects of Digitized Information Flows in the Logging Industry,* Licentiate Thesis, No. 1185, IDA-EIS, Linköping University, Institute of Technology.

18. **Hansson, Magnus (2005).** *From Dusk till Dawn – Three Essays on Organizational Closedowns*, Licentiate Thesis, No. 3, Örebro University.

19. **Verma, Sanjay (2005).** *Product's Newness and Benefits to the Firm – A qualitative study from the perspective of firms developing and marketing computer software products,* Licentiate thesis, No. 54, Mälardalen University.

20. **Sundén, Susanne & Wicander, Gudrun (2005).** *Information and Communication Technology Applied for Developing Countries in a Rural Context – Towards a Framework for Analyzing Factors Influencing Sustainable Use*, Licentiate thesis, KUS 2006:69, Karlstad University.

21. **Käll, Andreas (2005).** *Översättningar av en managementmodell – En studie av införandet av Balanced Scorecard i ett landsting,* Licentiatavhandling, No.1209, IDA-EIS, Linköpings universitet, Tekniska Högskolan.

22. **Mihailescu, Daniela (2006).** *Implementation Methodology In Action: A study of an Enterprise Systems implementation methodology,* Licentiate Thesis, No.1233, IDA-EIS, Linköping University, Institute of Technology.

23. **Flodström, Raquel (2006).** *A Framework for the Strategic Management of Information Technology*, Licentiate Thesis, No.1272, IDA-EIS, Linköping University, Institute of Technology.

24. **Werelius, Sofie (2006).** *Consumer Business Relationship with Retailer and Etailer for the Purchase of Clothing – A Network Perspective*, Licentiate Thesis No. 45, Uppsala University, Department of Business Studies.

25. **Fryk, Pontus (2007).** *Beyond IT and Productivity – Effects of Digitized Information Flows in Health Care*, Licentiate Thesis, No. 1328, Linköping University, Institute of Technology.

26. **Sandström, Sara (2008).** *Technology-based service experiences - A study of the functional and emotional dimensions of telecom services*, Licentiate Thesis, KUS 2008:3, Karlstad University, Faculty of Economic Sciences, Communication and IT**.**

27. **Lundmark, Erik (2008).** *Organisational Adoption of Innovations – Management Practices and IT*, Licentiate Thesis, No. 1352, Linköping University, Institute of Technology.

28. **Anjou, Anette (2008).** *Scanias framgång - Betydelsen av strategisk kongruens och integrerad styrning*, Licentiatavhandling, No. 1364, Linköpings universitet, Tekniska högskolan.

29. **Numminen, Emil (2008).** *Software Investments under Uncertainty - Modeling Intangible Consequences as a Stochastic Process*, Licentiate Dissertation Series, No. 2008:7, Blekinge Institute of Technology.

30. **Bergqvist, Linda (2008).** *A Conceptual Framework for Studying the Successful Outcome of the IS Outsourcing Process from a Relationship Perspective,* Licentiate Thesis, KUS 2008:30, Karlstad University, Information Systems, Faculty of Economic Sciences, Communication and IT.

31. **Wingkvist, Anna (2008).** *The Quest for Equilibrium - Towards an Understanding of Scalability and Sustainability for Mobile Learning*, Licentiate Thesis, No. 08118, Växjö University, Center for Learning and Knowledge Technologies, Department of Information Systems, School of Mathematics and System Engineering.

32. **Sundberg, Klas (2009).** *Atlas Copcos strategi och styrning - verktyg som ger guld***,** Licentiate Thesis, No. 48, Uppsala universitet, Företagsekonomiska institutionen.

33. **Mörndal, Marie (2009).** *"Hallå! Jag känner mig ensam här". En studie om studieovana studenters interaktion på ett webbaserat diskussionsforum,* Licentiate Thesis No. 113, Mälardalens högskola.

34. **Svensson, Martin (2010).** *Routines for Engagement – Emotions and Routines when Communicating through ICTs,* Linköping Studies in Science and Technology, Thesis No. 1444 LiU-TEK-LIC 2010:15.

35. **Mansour, Osama (2011).** *Share with Social Media - The Case of a Wiki,* Licentiate Thesis, School of Computer Science, Physics, and Mathematics, Linnaeus University, Växjö.

36. **Gullberg, Cecilia (2011).** *Puzzle or Mosaic? On Managerial Information Patterns*, Licentiate Thesis, Linköping University, Institute of Technology. Licentiate Thesis, ISSN 0280-7971; 1483.

37. **Kajtazi, Miranda (2011).** *An Exploration of Information Inadequacy: Instances that Cause the Lack of Needed Information,* Licentiate Thesis, School of Computer Science, Physics, and Mathematics, Linnaeus University, Växjö.

38. **Eklinder-Frick, Jens (2011),** *Building Bridges and Breaking Bonds: Aspects of Social Capital in a Regional Strategic Network*, Licentiate Thesis No 139, Mälardalen University.

39. **Hansen, Therese (2012).** *Internet or Traditional Stores: Identifying Influences on Consumers' Mobile Phone Purchases*, Licentiate Thesis No. 50, Department of Business Studies, Uppsala University.

40. **El-Mekawy, Mohamed (2012),** *From Societal to Organizational Culture: The Impact on Business-IT Alignment*, Licentiate Thesis, Department of Computer and Systems Sciences, Stockholm University.

41. **Hadjikhani, Annoch (2013),** *Expectations in the Internationalization Process: The case of two Swedish banks' foreign activities 1995-2010*, Licentiate Thesis, Mälardalen University.

42. **Salavati, Sadaf (2014),** *Novel Use of Mobile and Ubiquitous Technologies in Everyday Teaching and Learning Practices: A Complex Picture*, Licentiate Thesis, Linnaeus University.

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