Mobile, location-based games for learning

Developing, deploying and evaluating mobile game technology in education

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Abstract

Recent developments in mobile technology have facilitated the emergence of a vast number of games to be played on mobile phones. Several mobile games have also been developed with the explicit purpose of being used for learning. Studies of the educational practices related to these mobile games are not extensively available, however. The main aim for this research was to explore how mobile, location-based games can be used to facilitate teaching and learning practices within education. In particular, the aim was to fill the research gap on educational practices with mobile, location-based games, with an emphasis on mediated, situated social interaction with these games. For this purpose the technological framework of SILO — an authoring tool for creating location-based games — and the game Premierløitnant Bielke were designed, enacted and evaluated. Engagement with the game was studied in three different settings: first, with regard to usability and educational potential of the game; second, with regard to the opportunities for countering the experience of "one-timeness" of game playing and integration with other classroom tools and activities; and third, with regard to gaining insight into the interactional organisation and practical accomplishment of gameplay to discover what the players were actually doing when playing the game. A fourth study explored the educational potential of students creating location-based games for each other to play using the SILO framework.

Inspired by design-based research, the methodological approach was to study naturally occurring gameplay in order to inform and improve, in practical ways, the design of both the technology and the activities within the scenarios in which the games were embedded. Based on a view of learning as a situated, mediated and socially originated phenomenon, an ethnographically inspired approach to data collection and analysis was adopted, with the view that learning practices should be studied in light of the context in which they take place. This choice was supported by the observation that the data material on learning practices with mobile, location-based games for learning is still relatively scarce. Therefore, explorative studies that

can lead to knowledge about the social practice of location-based gaming and how to use them in educational institutions are valuable. The results indicate that learning by playing mobile, location-based games seems to be motivating and engaging to students, gameplay relies on a varied set of skills, and it is possible and inspiring to integrate student game creation into classroom activity.

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I dedicate this work to my late brother Lars Wake.

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Contents

1. Introduction

> "They [teachers] give the pupils something to do, not something to learn; and the doing is of such a nature as to demand thinking, or the intentional noting of connections; learning naturally results" (John Dewey, 1916, p. 229.).

In recent years, developments related to mobile technology have facilitated the emergence of a vast number of games to be played on mobile phones. These games use a wide range of the available functionality on mobile devices, from arcade-like games relying on a device's processor, screen and input-devices, to games that use a GPS unit, gyro, Wi-Fi and maps. Several mobile games have also been developed with the explicit purpose of being used for supporting learning in informal and formal educational settings. While such developments are motivated by the understanding that engagement with games and the use of devices that most students already possess can facilitate learning, there is a research gap between these convictions and an understanding of the role that such mobile games have for learning as well as their place in education. Thus, there is a need for studies focused on the conditions for learning enabled by mobile games. This research study is an explorative and empirical approach to discovering the educational potential of learning with mobile games by studying the design, implementation and use of a mobile, location-based game designed for learning the subject of history.

In the last two to three decades, computer games have become an increasingly important cultural phenomenon. For example, Prensky (2001) described the young generation as digital natives and noted that computers are considered a naturally embedded part of youth culture. Several other authors (e.g. Fromme, 2003; Gee, 2003) have highlighted that computer games are a significant element of computer use for the same generation. The gaming industry, and its computer games, is becoming an increasingly significant cultural phenomenon or an "enculturation force" (Halverson, Shaffer, Squire, & Steinkuehler, 2006, p. 1049).

Researchers have investigated the use of computer games in education and how games can be used to facilitate learning processes in particular (see e.g. McFarlane, Sparrowhawk & Heald, 2002; Mitchell & Savill-Smith, 2004; Kirriemuir & McFarlane, 2004; Shute, Rieber, & Van Eck, 2011). Egenfeldt-Nielsen (2006) categorized these efforts as follows according to differences in the computer games: *learning with commercial games*, *learning with commercial educational games* (edutainment) and *research-based educational games*. Each category has a distinct set of challenges related to its use for learning. For example, both game players and teachers largely avoid edutainment and research-based games, whilst often being based on an interesting learning-related idea or observation typically lack the professional production apparatus behind most commercial titles and the accompanying advantages (Egenfeldt-Nielsen, 2006). Schools, however, are increasingly interested in embracing this everyday technology within school settings, creating bridges between the uses of technology at home and at school.

The emergence of the research field of mobile learning (ML) (Sharples, Taylor & Vavoula, 2007; Pachler, Bachmair & Cook, 2010) has partly been facilitated by developments in mobile technologies, both in terms of 1) the adoption rate and use of mobile phones and devices by almost all segments of society (see for example Ling, 2004), regardless of age, gender or level of education; and 2) the increasing functionalities being offered on mobile phones and devices. Mobile phones can no longer be regarded exclusively as devices for facilitating verbal communication between users on the move, but rather as small but powerful mobile computers and media devices, where it has become basically impossible to see the limit to the range of potential use. Van't Hooft (2008) identified several uses, including "accessing and aggregating information online, navigating the physical environment, interacting with the physical environment, communication, entertainment and media creation" (p. 33). Given the multitude of uses, Pachler, Bachmair and Cook (2010) argued that the current naming of the device, "mobile phone", will change at some point in time, in the same manner as the horseless carriage evolved to be called the automobile.

A parallel and perhaps related technological development is the emergence of technologies that can be described as pervasive or ubiquitous. Ubiquitous computing (Weiser, 1991) refers to technology and computer use that is not taking place in front of a screen connected to a stationary computer. Furthermore, it reflects how different aspects of the world are increasingly augmented with computer processing power, expanding the range of contexts in which we put computer power to use (Dourish, 2004). Pervasive or ubiquitous computing relies on devices for positioning the user, such as GPS or mobile network stations, and ways of facilitating information exchange relative to that position, such as through RFID tags or 2D barcodes.

Mobile, location-based games represent a new and emerging type of game that draws on the technological resources described as pervasive and ubiquitous computing and differs from traditional board games and video or computer games in several ways. In mobile, location-based games the physical and cultural surroundings, for example an urban area, are made an integral part of the game space, and the location of the gamers is a key aspect of the game-playing activity. Mobile, location-based games are made up of the physical world with an added digital layer, enabling the game players to explore possibly familiar surroundings from a new perspective. These games offer new and novel opportunities to facilitate learning experiences by embedding abstract concepts in their contexts of actual use (Kurti, Spikol, Milrad, Svensson & Petterson, 2007; Kurti, Milrad & Spikol, 2007).

Design-based research is a research tradition originating from the work of Ann Brown (1992) and Allan Collins (1992) on design experiments (Collins, Joseph & Bielaczyc, 2004). It has increased in popularity in recent years after an initial period of relative silence around the concept (Barab & Squire, 2004). Design-based research, not to be confused with design science (Hevner, March, Park & Ram, 2004) that shares some characteristics, implies a pragmatic approach towards engineering educational innovations, where the utility and usefulness of the designs are regarded as success criteria. According to Brown, engaging in design-based research entails both engineering new designs and studying the effects of the designs. For Brown (1992) the goal was achieving research-driven practical improvement of educational

designs. Barab et al. (2007) expand the scope of design-based research arguing that it is not only the artefacts, tools and curricula in educational practices that are changed through this kind of work, but at the same time a critical social agenda towards the same practices is involved. Thus, design-based research entails exposing what "could be" (Barab et al., p. 264) in addition to that which exists or not, in relation to the socio-political aspects of curriculum and school practices.

Based on the background described above, this research investigates how mobile, location-based games can be used to facilitate learning processes in educational settings and explores their potential for educational use. A mobile, location based game called Premierløitnant Bielke (PB) and SILO, an authoring tool for creating such games, were designed, developed and deployed in different settings. Based on a view of learning as a socially originated, collaborative and situated phenomenon (Suchman, 2007; Lave & Wenger, 1991), ethnographically oriented data were constructed by studying the game and game technology in use. Analysis of the data informed the redesign of both the game technology and the situations in which the technology was used.

The overall research question that guided the research is:

How can mobile, location-based games be used to facilitate learning?

This question was addressed through four studies, each with its own focus, set of challenges, iteration of technology development and approach to the gaming. A contextualisation of each study regarding how it relates to the main research question is provided in Chapter 5, and a discussion of how each study have informed the main research question is provided in Chapter 6.

Study 1: This study focused on the use of mobile, location-based technology in a collaborative gaming session and on how it was perceived by the participants.

Study 2: The focus of this study was on how the location-based game of PB could be integrated with classroom technologies and activities.

Study 3: This study focused on the practical accomplishments of collaborative gameplay. More specifically, it examined how the participants engaged with the material presented in the game, how they used the resources available to them, and how they communicated and coordinated their activity.

Study 4: The focus of this study was on the educational potential of students making location-based games for each other in order to learn the subject of history.

The dissertation is structured in two parts. Part I comprises the background and methods as well as a reflection on the results and contributions of the work. Part II consists of three internationally peer-reviewed articles and one article currently being reviewed; each article reports on one of the studies.

Chapter 2 describes the field of ML, with emphasis on theoretical works particular for mobile learning, research issues and related theoretical works that have been relevant for this research. Chapter 3 presents the main research methods and data collection techniques used for this research, with an emphasis on design-based research. Chapter 4 presents the design and implementation of SILO — the authoring tool for creating mobile, location-based games developed for this research. It also introduces a game that has been made and studied in several iterations using this authoring tool — Premierløitnant Bielke (PB). Chapter 5 contains an overview of the four studies that have been carried out in the course of this research. A discussion of the main findings and an evaluation of the research are provided in Chapter 6.

2. Theoretical Influences on the Research

Chapter 2 provides an overview of the emerging field of ML, as it is related to the more general field of technology-enhanced learning (TEL). The overview is focused on theory-forming works and research issues. Theoretical concepts that have influenced this research are presented following the presentation of the theory-forming work of ML, after which the current research issues and how they relate to this research is presented.

2.1 Technology Enhanced Learning

TEL is an umbrella term used to describe endeavours with developing, implementing and evaluating use of (usually digital) technology to support and facilitate teaching and learning. The concept of TEL is broad, multifaceted and multidisciplinary, and covers a range of sub-fields and perspectives on the use of technology to support and facilitate learning, such as computer support for collaborative learning (CSCL) (Stahl & Hesse, 2010). Balacheff, Ludvigsen, de Jong, Barnes and Lazonder (2009) argued that TEL has grown from five main areas of research, each contributing to the overall understanding of TEL:

1) *The design area*: with a focus on the design and co-evolution of new learning activities;
2) *The computational area:* with a focus on what technology makes possible;
3) *The cognitive area:* with focus on what the individual can learn under certain conditions in different contexts;
4) *The social and cultural area:* with a focus on meaning-making, participation and changes in activities in schools, universities, workplaces and informal settings;
5) *The epistemological area:* with a focus on how the specificities of the domain impact the design and use of technologies.

ML is a specific area of research within TEL that focuses on how mobile and handheld devices feature in learning environments.

2.2 Mobile Learning: Theoretical Perspectives

ML is an relatively new research field that has emerged over the last 10 years (Sharples, Arnedillo-Sánches, Milrad & Vavoula, 2009; Zurita & Nussbaum, 2007; Pea & Maldonado, 2006), although Sharples et al. (2009) assigned Alan Kay's Xerox Dynabook project, started in 1968 (Kay, 1972), as the first attempt to design mobile learning environments. Research has focused on mobile device support for learning in the classroom (Chang, Wang, Chen & Liang, 2009; White, 2006) to support learners in the field (Brugnoli, Morabito, Bo & Murelli, 2007; Lyons, 2009; Yatani, Onuma, Sugimoto & Kusunoki, 2004). Even though it is a young research field, several specialist conferences (e.g. mLearn Mobile and Contextual Learning, IADIS Mobile Learning and IEEE Wireless, Mobile and Ubiquitous Technologies in Education), international, peer-reviewed journals (e.g. the International Journal of Mobile and Blended Learning, the International Journal of Mobile Learning and Organisation and the International Journal of Mobile Human Computer Interaction) and a community organisation (IAmLearn – International Association for Mobile Learning), have already been established. Initially, ML took the technology as the starting point for providing a definition of the field, meaning learning that is facilitated by mobile devices. Recently, definitions that underscore not only the mobility of learners, but also the mobility of information and knowledge have become more common (Traxler, 2007). Theoretical accounts of ML have also been developed, and the following sections of this text will deal with two such accounts.

2.2.1 Theoretical and conceptual frameworks for ML

Several authors (Shuler, 2009; Klopfer & Squire, 2003, Zurita, Nussbaum & Sharples, 2003; Naismith, Lonsdale, Vavoula & Sharples, 2004) have pointed out that that currently there is no single, widely accepted theory of ML. However, two recent,

somewhat contesting attempts at providing theoretical accounts that are unique to ML can be identified. This section presents these and contrasts them with theoretical concepts that have informed this research. Several studies have also relied on existing theoretical works, such as activity theory (see e.g. Uden, 2006; Wali, Winters & Oliver, 2008; Waycott, 2004; Zurita & Nussbaum, 2007). These works are not discussed in detail in this chapter. Rather, related theoretical concepts that have influenced this work are presented, in a discussion of the two theoretical accounts of ML. As several theories and perspectives on learning exist already, it is pertinent to hold forthcoming theories of ML against this backdrop.

A Theory of Learning for the Mobile Age

Sharples, Taylor and Vavoula (2007) offered a theoretical account of ML where they highlighted learning as enabled by mobile people and technology, arguing that learning rises from social experience and that education also occurs in other places than in a traditional classroom mediated by a teacher. Their primary rationale for developing a theory of ML is the current changes associated with people and mobile technology in society in general. This refers to the vast penetration of numbers and types of mobile computing devices, with the mobile phone being the primary but not only device, the multitude of possible and actual uses for such devices, and also the increasing instances of embedded, pervasive or ubiquitous computing devices — devices that offer information processing dependent on a location or place. Building on two main theoretical sources, Laurillard's (2002) concept of learning as conversations and activity theory (Engeström, 1987), they define ML as "the processes of coming to know through conversations across multiple contexts amongst people and personal interactive technologies" (Sharples, Taylor & Vavoula, 2007, p. 225).

The two concepts from their definition that they expand in their theoretical account of ML are *conversations* and *context*. Their understanding of the concept of *conversation* originates in the conversation theory of Gordon Pask (1975), a theory that advocates for the alignment of learners and interactive computation mediums and

the need for learners to externalise their understandings of a phenomenon in order for learning to take place. Building on the work of Pask, Laurillard (2002) created a framework of learning as conversations. An adaption of this framework (Sharples, Jones & Vavoula, 2007) is modelled below (see Figure 2.1). The conversational framework is meant to describe the process of coming to know through a conversation, which takes place between a *learner* and a *partner*. Although the model describes the conversation as taking place between two parties, many conversations only take place on the *learner* side of the model, in cases where the learner does not have a conversation partner. The conversation partner can be a teacher, another learner or interactive computer technology. Holding computer technology as a *partner* in a dialogue follows from building on Pask's conversation theory, which aligns people and technology, but Sharples, Jones and Vavoula (2007) do not see the computer as capable, for example, of engaging in developing a shared understanding, or holding a conversation at the "Level of Descriptions" (see Figure 2.1).

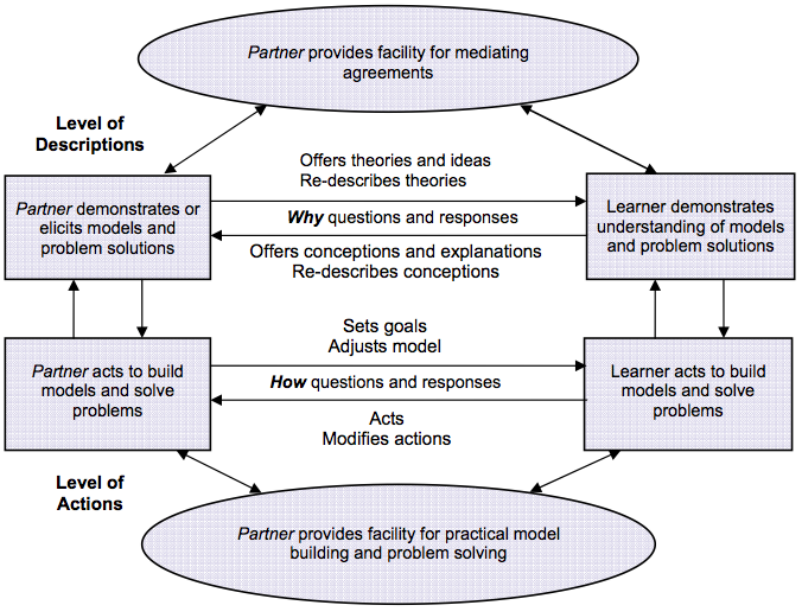

Figure 2.1: A conversational framework for learning with technology (Sharples, Jones & Vavoula, 2007).

Sharples, Jones and Vavoula's (2007) model aims to capture how conversations are taking place at two levels: the *level of descriptions* and the *level of actions*. As mentioned above, the conversations can take place between a partner and a learner, but also between the two levels for a learner by him or herself. At the *level of actions*, a learner and a partner can converse about the carrying out of an educational activity and establish a shared understanding of the phenomenon. At the *level of description*, the partner and the learner discuss the implications and meanings of the actions in order to make sense of the activity, through a "process of proposing and re-describing theories, and offering and adjusting explanations" (Sharples, Jones & Vavoula, 2007, p. 228). In addition, learners and partners can hold an internal dialogue, making sense of the activity. Technology can provide or enrich the environment in which the conversations take place, for example by being a partner in a limited dialogue at the level of action in cases of computer assisted instruction (CAI) or by providing a rich environment for conversation in general. One example is providing data collection tools and building models for a group of learners.

Regarding the concept of *context*, Sharples, Jones and Vavoula (2007) highlighted how context is continually created through interaction and thus always changing. However, they also argue that context can be solidified temporarily, for example by forming social networks between people with shared interests, by deploying or modifying objects to create workspaces or by arriving at a shared understanding of a problem. A central concern within ML is how to create stable contexts for learners, as compared to the perceived stability of the context of a classroom in traditional school-based learning situations, characterised by a fixed location, a single teacher and agreed upon curriculums.

Sharples et al. (2009) expanded the original definition of ML provided by Sharples, Jones and Vavoula (2007) by including the concept of *exploration*. They described exploration as an essentially mobile phenomenon, as it typically involves movement in a physical or conceptual space, where experiences and concepts are linked into new knowledge. In consideration of this, *conversation* represents the bridge that enables learning within and across the different contexts, through discussions that

build on ideas formed in different settings, or by making notes in one particular setting to be used in another place and at a later time (Sharples et al., 2009).

The instability of context in ML, according to Sharples, Jones and Vavoula (2007), makes the historical construction of context more important and explains how a current activity can only be fully understood within a historical perspective and how it has been shaped and transformed by previous ideas and practices (Engeström, 1999). Hence, Sharples, Jones and Vavoula (2007) analysed learning as a tool-mediated, cultural-historical activity system that supports learners in the goal-directed activity of transforming their knowledge and skills, as modelled in Engeström's model of the activity system (1987). To explain the role of ICT in learning, Sharples, Jones and Vavoula (2007) modified Engeström's activity system by separating two layers of tool-mediated activity (see Figure 2.2) into a semiotic and a technological layer. That is, each "corner" of Engeström's activity model is separated into a semiotic and a technological component. The semiotic layer describes learning as a semiotic system in which learners' object-oriented actions are mediated by cultural tools and signs. The technological layer shows learning as an engagement with technology, in which ICTs function as interactive agents in the learners' process of coming to know.

Sharples, Jones and Vavoula (2007) specified two purposes for separating the activity system model into two layers. The model can either represent a tool for entering discussion with educational theorists (semiotic layer) or software developers (technological layer), or it can alternatively be used to examine the process of learning as the interaction between people and technology as a holistic system, by way of superimposing both layers on the same model (see Figure 2.2). The authors claimed that they were arguing neither for a separation or fusion of the semiotic and the technological, but that by moving the layers apart, they hoped to create a device that could drive forward the analysis of ML.

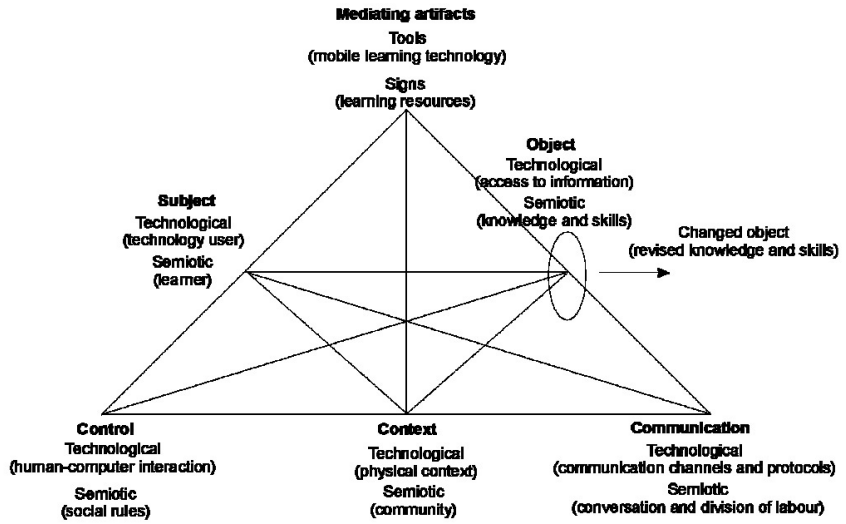

Figure 2.2: A framework for analysing mobile learning (Sharples, Jones & Vavoula, 2007).

As can be seen in the adapted model of the activity system reproduced above, the nodes in Engeström's original model named Socio-cultural Rules, Community and Division of Labour have been renamed to *Control*, *Context* and *Communication*. This is based on the belief that using the original terms would hinder rather than foster communication between educational theorists and technology designers, because of their Marxist origin. *Control* refers to who controls the learning situation and may rest with the teacher or be distributed between groups of learners. Rules and conventions still apply within this corner of the activity system. *Context* is used to refer to the many communities of actors who interact with shared objectives, mutual knowledge, strategies for learning and so on. *Communication* highlights the dialectical relationship between the technical and semiotic layers, as technological systems may enable certain forms of communication to which learners begin to adapt. As learners become more fluent in the particular way of communicating that the system enables, they begin to adapt it, for example by adding emoticons in e-mail.

Finally, Sharples, Jones and Vavoula (2007) remarked that the entrance of mobile technology with vast opportunities for creating and sharing information and communication can represent a challenge to the traditional classroom as a central place for learning and education, and they provided examples of how schools have reacted negatively to children bringing and using mobile phones in schools. They recognised that their theory lessens the role of the teacher as an "ontologically privileged person" (Sharples, Jones & Vavoula, 2007, p. 243) and recasts the teacher's role to that of a conversation partner.

A Socio-cultural Ecology: Agency – Cultural Practices – Structures

Pachler, Bachmair and Cook (2010) saw the need for developing and providing a new theory of learning, as the conditions for education, and possibly for learning in general, have fundamentally changed due to the widespread introduction of mobile devices and mobile use practices between young people. This is partly facilitated by the increasing portability, ubiquity, abundance and functional convergence of these devices, and the view that existing theories of learning fail to provide adequate accounts of learning when mobility is brought into the picture. In addition, similar to Sharples, Taylor and Vavoula (2007), they are interested in providing an account of how the boundaries between instances of learning in formal education and learning in informal settings are increasingly being blurred, almost to the extent where it no longer makes sense to make a distinction between the two (Pachler, Bachmair & Cook, 2010).

Pachler, Bachmair and Cook's (2010) theory of socio-cultural ecology is a theoretical account or conceptual framework partly inspired by the work of the sociologists Ulrich Bech and Anthony Giddens, and partly by Lev Vygotsky and Jean Piaget. However, it differs from that of Sharples, Taylor and Vavoula (2007) in several other ways. While the authors recognize that learning with mobile phones might well be studied as an instance of TEL, or under similar umbrellas, they provide several arguments for why mobile devices are different to other tools that feature in TEL environments and thus argue for developing a separate theoretical or conceptual

model for ML. One argument arises from the characteristics of mobile devices: “the convergence and functions into a single device, its ubiquity and abundance, portability and multi-functionality” (Pachler, Bachmair & Cook, 2010, p. 6). In other words, they argue that it is a tool with unlimited potential instances of use. Second, most Western young people already own at least one mobile phone or device. Third, mobile technology permits the crossing of boundaries and contexts in relation to learning; in other words, one device or technology can be used in several different settings. A fourth important reason for Pachler, Bachmair and Cook (2010) is the need for educational institutions to provide a response to social and cultural changes related to media structures on a macro-level, where the world is seen as increasingly fluid, provisional and unstable.

Pachler, Bachmair and Cook (2010) proposed their theoretical and conceptual framework for ML based on a review and critique of other dominant theoretical frameworks used in ML, for example activity theory, and Sharples, Taylor and Vavoula’s (2007) use of Laurillard’s (2002) conversational framework. Their critique of activity theory is that it is too abstract and not tangible enough, and they believe it to be more fruitful to direct attention towards the *subject* rather than the *object*. Furthermore, they argue that fruitful employment of activity theoretical analyses requires an engagement with the political and philosophical roots of activity theory, and there is no evidence of this in the field of ML so far.

Pachler, Bachmair and Cook (2010) defined ML as “(…) the processes of coming to know and being able to successfully operate in, and across, new and ever changing contexts and learning spaces. And, it is about understanding and knowing how to utilize our everyday life-worlds as learning spaces” (Pachler, Bachmair & Cook, 2010, p. 6). Their criteria for an ML theory’s usefulness are its operationalisability, or its ability to be transformed to something more concrete and practical as well as whether it “articulates with the professional life-worlds of teachers/educators” (Pachler, Bachmair & Cook, 2010, p. 156).

Rather than describing learning with mobile phones as a condition for learning, Pachler, Bachmair and Cook (2010) regarded it as a potential educational response to complex changes in society, socialisation and the media. Building on the sociological work of Anthony Giddens and Ulrich Beck, they saw the emergence of learning with mobile phones as appearing in relation to individualisation in a risk society (Giddens, 1999; Beck, 1992) and changes in structures of media organisation in society. The ongoing changes in these structures are characterised by a shift in the organisation of mass communication, from ”institutionally centralised editorial systems to an individualised ‘mobile’ system for generating content and contexts for learning” (Pachler, Bachmair & Cook, p. 155). These macro-processes of organisational media change and changes in the relationship between the subject and society (individualisation) are additionally characterised by new media tools. These new media tools are portable and functionally convergent, with adhering patterns of appropriation around “personally motivated use of media and knowledge within individual frames of everyday life as well as individualised developmental perspectives” (Pachler, Bachmair & Cook, 2010, p. 155).

Furthermore, the authors argued that the emergence and use of these new tools are employed in knowledge generation and meaning-making characterised by learner agency. Learner agency is seen as a logical continuation of individualisation and individualised mobile mass communication rather than a pedagogic choice (Pachler, Bachmair & Cook, 2010). Media are regarded as cultural resources, which are important in the development of children as members of society, which explains the authors’ choice of naming their theoretical and conceptual contribution to the field of ML socio-cultural ecology. The primary question is not how to design the use of mobile devices for students’ learning situations, although that is also important, but rather how people appropriate mobile technologies in general. By focusing on appropriation, the authors focused on “the processes ‘learners’ engage in when using mobile media within existing or new cultural practices of everyday life or educational institutions” (Pachler, Bachmair & Cook, 2010, p. 156). Appropriation is closely linked to learning and is understood as a process of meaning-making within social structures, cultural practices and learner agency, as modelled below (see Figure 2.3).

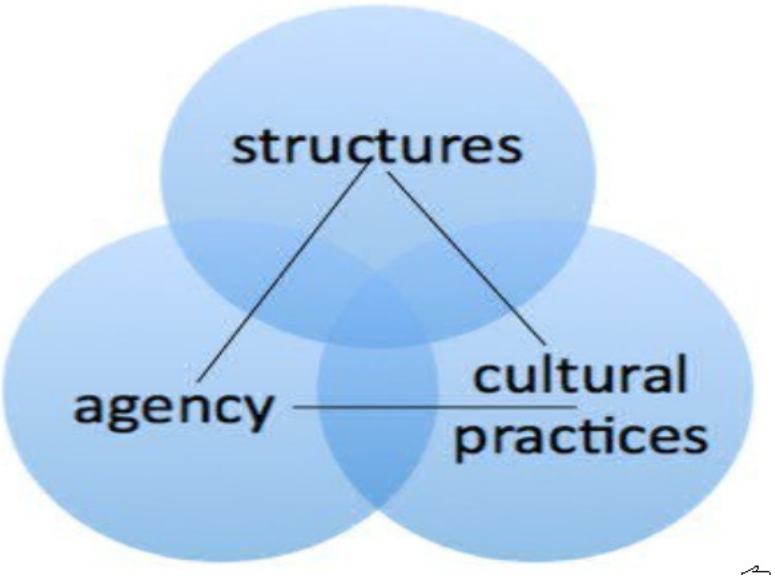

Figure 2.3. Key components of a socio-cultural ecological approach to mobile learning – a typology (Pachler, Bachmair & Cook, 2010).

Pachler, Bachmair and Cook's (2010) model of socio-cultural ecology comprises the non-hierarchical elements agency, cultural practices and social structures, where the elements in the model are to be read non-hierarchically. *Agency* refers to an individual's capacity to act on the world. It is a learner's social and semiotic capacity, or their technology-mediated ability to form relationships with others, and their ability to make meaning and develop representations of the world using sign systems, such as language. As an example they highlighted how young people are increasingly seeing their environment as a resource for learning and how the world itself is the curriculum. *Cultural practices* emphasises how mobile devices are increasingly being used for social interaction, communication and sharing, where learning is regarded as culturally situated meaning-making both within the context of educational institutions and outside, and media use in everyday life has achieved cultural significance. *Structures* refer to social structures that influence the life-worlds of young people in everyday life. The authors highlighted that young people increasingly live in a world of individualised risks, that new social stratifications are emerging, that mass communication is becoming individualised and mobile and that it is mediated by a

highly complex technological infrastructure. Finally, the learning of young people is very much governed by curricular frames of educational institutions with their specific approaches towards the use of new cultural resources for learning.

Regarding how the process of learning actually occurs, Pachler, Bachmair and Cook (2010) provided descriptions inspired by the work of the developmental psychologists of Lev Vygotsky on one hand and Jean Piaget on the other. One of their main conceptual constructs related to learning is that of *appropriation*. Appropriation is seen as the main process of arriving at formations of reality in a learner. Appropriation refers to the internalisation of objectified symbolic activities. Appropriation defines the social character of the development of a human being. Like Vygotsky, they viewed the development of a child as a socially negotiated process of appropriation of cultural products. They argued that this occurs in a context similar to that Vygotsky called zone of proximal development (Vygotsky, 1967), which highlights how learning is socially mediated, rather than being a matter of the naturally unfolding of an innate potential, and that learning must be designed and facilitated with respect to the learners' current level of development.

Instead of using the concept of the zone of proximal development, however, Pachler, Bachmair and Cook (2010) preferred the term responsive situations. They argued that in light of recent developments associated with mobile technology such as media convergence, the idea of developmental zones no longer can be exclusively seen as temporal or taking place in time and that the concept of the developmental zone therefore has to be revisited. Additionally, the concept of cultural products needs to be reconsidered and extended to include situative contexts, which include contexts that are user-generated and socio-cultural milieus that are connected to both traditional and new media. With mobile devices, contexts become connected to a tangible interface, in addition to tools for navigating them, as well as communication and action. The authors argued that the assimilation of mobile contexts should be regarded as responsive zones of child development, where the new cultural products of mobile contexts provides new options for child development if they are appropriated as cultural products by the child.

Appropriation, in the context of learning with mobile devices, thus involves the processes relevant to the development of personal practices with mobile devices. The processes referred to are interaction, assimilation, accommodation and change (Pachler, Bachmair & Cook, 2010). These processes are aligned with Piaget's (1955) description of learning and perception as a perpetual effort of a learner to adapt to the environment in terms of accommodation and assimilation. Assimilation is when a learner takes something unknown into his or her cognitive structures, while accommodation is changing the cognitive structures to make sense of the environment. The process of appropriation is viewed as emergent; practice is central, and understood as the learner's engagement with a particular setting.

For schools to bring these cultural products of mobile contexts into practice, or one way of successfully adopting mobile learning practices, Pachler, Bachmair and Cook (2010) suggested that user-generated contexts should be viewed as conversational threads. Conversational threads are the "thematic options enabling the connection of the fragmented life-worlds outside of school with curricular learning inside the school" (Pachler, Bachmair & Cook, 2010, p. 22). It is argued that young learners are increasingly and actively engaged with creating their own forms of individualised contexts generated for learning, termed learner-generated contexts. The trend is that users of mobile devices can generate their own content in the form of text, pictures or video clips, which they can publish on the Internet in various platforms or forums, where they are seen as the originator of the content. Thus, this phenomenon can be described as an "individualised communication context" (Pachler, Bachmair & Cook, 2010, p. 23), to which several traditional media providers are beginning to respond. In addition to the individualised production of content, mobile users are also producing contexts that position them in new relationships with space, the physical world, place and social space.

Two different theoretical accounts of ML have been presented, and both endeavour towards developing a distinguished theory for the research field of ML. Traxler (2007) argued that even though, as a research community, the field of ML may feel the need for a unifying theory, it may still be problematic to achieve since ML is a

"noisy phenomenon, where context is everything" (p. 6), in the sense that there are too many different instances and cases of ML to describe them in a coherent manner. Moreover, in the related TEL field of CSCL (Stahl & Hesse, 2010), a multitude of theoretical approaches and foundations coexist. It is not the point of this discussion to establish whether a theory of ML is needed, however, but rather to point to how theoretical concepts have informed the research conducted.

2.3 Design of Practice

This research involves the development, deployment and redevelopment of mobile technology for school use, the phenomenon of learning with mobile devices and learning where learners' mobility is involved. The learners' activities have been considered as part of a *practice,* a practice which in this case has had the particularity of being partially characterised by the mobility of practitioners and the tools they use. When considering practices in relation to human work and learning, a wide body of theoretical works to build on is available, such as socio-cultural psychology (Cole & Engeström, 1993), activity theory (Engeström, 1987; 1999; Kaptelinin & Nardi, 2006) and communities of practice (Lave & Wenger, 1991). Here, concepts from Susanne Bødker's (1991) interpretation of activity theory are highlighted, as her work is directed at the *design* of computer-based artefacts, within the Scandinavian tradition of participatory design, or what she labels the Aarhus-Oslo school.

Building on her interpretation of Leontiev's work on a theory of human work activity to inform the relationship between people and digital technology, Bødker (1991) defined a practice as a "collective activity with a specific object or goal" (p. 28) conducted by a group of human beings. Practice, furthermore "arises from, and is carried by, some common goal or object, as well as by the conditions of the collective activity" (p. 28). Examples mentioned are material and organisational conditions and the means of the activity. Practice is reflected in the repertoire of operations available to an individual member of a group, but the individual member also takes part in constituting and reproducing the group's practice through his or her actions and

operations. It refers to what an individual teacher or student *does*, but also to what multiple teachers or students *do.* The object of study in this research then becomes the collective activity of students interacting with and through a mobile game for the purpose of learning.

Artefacts mediate action toward another subject, or human being, or object (Bødker, 1991). They are normally not objects in themselves, except for cases of learning or rediscovering an artefact; artefacts are "what they are meant *for*" (p. 34, italics added). Mediation refers to transforming an object instrumentally, but also to communication. Bødker (1993) argued that computer applications should not be studied as things, but rather in terms of how they mediate use. Bødker (1991) developed the notion of the *computer-based artefact*, based on the original concept of the artefact. Although from an activity-theoretical viewpoint, the "computer is no different than other mediators" (Bødker, 1997, p. 149.), computer-based artefacts are distinguishable from the traditional socio-cultural understanding of artefact, as they are developed over a shorter time-span, complex in construction, and designers are not normally part of the user community. They also decrease the directness of the mediation between the subject and the object, as they are experienced through their representations given by the computer application. Accordingly, computer applications can support mediation between several objects and subjects.

The theoretical constructs of *practice* and *artefacts* help limit and concretise the object and level of study. The object of study is, for example, not the tool or artefact in isolation, as in the mobile game PB or authoring tool SILO in itself. Nor is it the learning outcome in isolation, as in changes in a student's knowledge, represented by a grade or score, for instance. It is rather how PB, or SILO, features in the practice of students and teachers in a classroom and what kind of activities it facilitates. This should be understood in relation to how the tools, or artefacts, are being used.

Bødker (1991) argued that when designing for future uses of technology, it is important to understand the current use practices in the area that the designer is addressing through developing new tools, or to "*start out from the present praxis of*

the future users" (Bannon & Bødker, 1991, p. 242, italics in original). The design of computer-based artefacts is directed towards a future use situation, but also entails taking the present practices as a starting point, as the need has arisen from their experiences. Bødker (1991) stressed that the design process is a process of learning, both for the designers, who must learn about the practices of the user group, and the user group, who in turn need to arrive at an understanding about what a developer can help with. Bødker (1991) also emphasised, in line with the participatory design tradition, that there are usually conflicting interests and perspectives between user groups of the same artefact, such as managers vs. manual labourers. These are relevant to the field of ML, as Sharples et al. (2007) pointed out that many schools ban mobile phones, while students are interested in using them.

Wasson (2007) applied Bødker's ideas about design of computer-based artefacts to the design of TEL environments. The design of TEL environments should take the institutional, pedagogical and technological aspects of the environments into account, and evaluating the activity that emerges from the design can be evaluated from institutional, technological and pedagogical perspectives (Wasson, 2007). Implications from this view are that the institutional and pedagogical aspects of the design process are of equal importance to the technology itself and that understanding the use is a "complex relationship between institutional, pedagogical and technological perspectives" (Wasson, 2007, p. 4.), as illustrated in Figure 2.4.

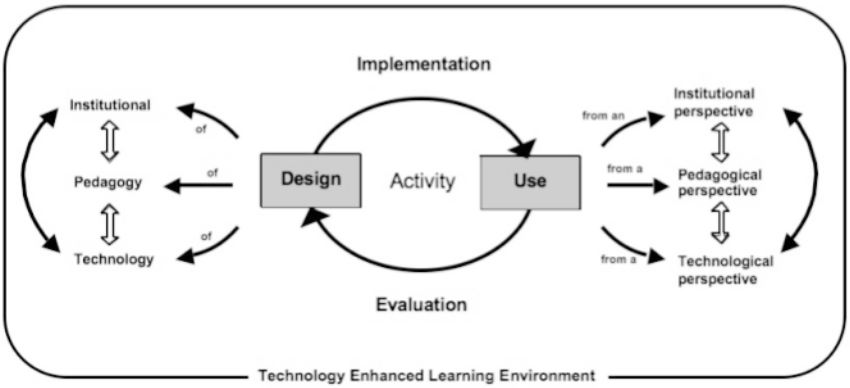

Figure 2.4. Design and use of technology enhanced learning environments (Wasson, 2007, p. 5).

This way of thinking about developing technology for learning purposes has inspired the work related to this thesis in several ways. Foremost, it illustrates the complexity of the associations between learning activities, artefacts and the contexts in which they reside. When developing a mobile, location-based game to facilitating learning, it becomes apparent that several issues, such as the organisational and pedagogical factors, must be considered in the design process, and may each in turn be studied in a number of different ways. Hence, for three of the studies involved, organisational/ institutional and pedagogical aspects of the learning activities have also been designed in conjunction with the gaming activity. For example, in Study 2, the gaming activity was designed to be a part of other learning activities in school, such as web publishing of material that the students gathered and created themselves.

Institutional, organisational and pedagogical aspects of the learning activity design manifestation have been taken into account when reviewing the outcomes of the learning activities that have taken place. For example, in Study 4, how the organisational aspect of integrating the learning activity into the portfolio of works and tests upon which the students would finally be graded affected the level of engagement with the designed learning activity was considered.

So far this chapter has presented the research field of ML as a part of TEL and focused attention on theoretical works within the field as well as current research issues including how this research relates to them. A contrasting theoretical perspective has been presented that emphasises the concept of practice, how design of artefacts must take the current use practices as a starting point, and how technological, institutional and pedagogical aspects relate to these practices. It has also been argued how this theoretical perspective informs the research that has been carried out. Next, research issues relevant to the field of ML are presented and discussed in relation to this research.

2.4 Research Issues in Mobile Learning

This section deals with research issues in ML. The topics that are discussed here should not be regarded as an exhaustive list of issues and discourses in the field, but rather as discourses that are considered especially relevant to this thesis and the work with developing, deploying and evaluating the mobile, location-based game of PB and the adhering SILO authoring tool.

Sharples et al. (2007) listed the following research issues in ML:

1) What is mobile learning?
2) How can mobile learning be enhanced without interfering with it?
3) What are affective factors in learning with mobile devices?
4) How can we address the conflicts between personal informal learning and traditional classroom education?
5) Evaluating mobile learning: What are the appropriate methods for evaluating learning in mobile environments?
6) How should learning activities using mobile technologies be designed to support innovative educational practices?

7) How can we integrate mobile devices with broader educational scenarios?

Pachler, Bachmair and Cook (2010) added the following issues:

1) Development and preparation of educational professionals.
2) Personal and privacy issues related to users.
3) How to describe context.
4) Opportunities for digital augmentation.

Pachler, Bachmair and Cook (2010), similar to Sharples et al. (2007), also included affective and motivational factors of learning with mobile devices, learning in informal vs. formal settings, design issues and methodological issues.

Glahn and Specht (2011) conducted an expert study in an attempt to structure the research problems that are associated with the field of mobile and contextual learning and characterise the field of research as consisting of three main research clusters: access to learning, contextual learning and learning across contexts. *Access to learning* refers to a set of research problems that address "access to learning opportunities and educational resources" (p. 192) and emphasise the mobility of learners as an aspect of enabling learning. *Contextual learning* emphasises the relation to learning and the setting in which it is situated, while *learning across contexts* emphasises transitions between contexts, and in particular between classroom and informal learning settings.

Generally, the issues raised by Pachler, Bachmair and Cook (2010) are more outwardly relevant, as learning with mobile devices is becoming more commonplace in education, while the issues raised by Sharples, Jones and Vavoula (2007) are more internally directed towards the ML research field. Kurubacak (2007) tried to identify research issues for mobile learning from the practitioners' perspective, by carrying out a Delphi study with online workers in distance education as participants. Kurubacak's lists of findings are too extensive to report here in full, but two issues,

consider the use of mobile learning technologies to support collaborative learning and *transform learning into a part of real-life,* were identified as the most important research needs for mobile learning from the practitioners' perspective.

Based on the lists identified above, the research issues that have been especially relevant for this research are:

1) What are the appropriate methods for evaluating learning in mobile environments?

2) How should learning activities using mobile technologies be designed to support innovative educational practices?

3) How can mobile devices be integrated with broader educational scenarios?

Evaluating mobile learning environments:

Taylor (2006) and Vavoula and Sharples (2008) made the point that, as ML is a relatively new research field, no common frameworks, methods or tools for the evaluation of mobile learning have been established. It is a distinguishing characteristic of the field that learners are spatially and temporally dispersed in the environment, accessing content where it may be found, which decreases opportunities of control for researchers, for example when compared to studying how personal computers are being used within a classroom setting. Furthermore, as learners are increasingly relying on their personal (mobile) devices, they may be less inclined to make these accessible for study. Vavoula and Sharples (2008) described the evaluation challenges as:

1) Capturing the learning context and learning across contexts

2) Measuring mobile learning processes

3) Respecting learner/participant privacy

4) Assessing mobile technology utility and usability

5) Considering the wider organisational and socio-cultural context of learning

6) Assessing in/formality

Sharples, Arnedillo-Sánchez, Milrad and Vavoula (2009) summed up the challenges for evaluating mobile learning as:

1) Unpredictability of the context of use

2) Unpredictability of the learning process

3) Unpredictability of the mode of use

4) Looking beyond the "wow" effect

The approach to evaluation taken in this research has first and foremost been justified by the novelty of the technology being developed and studied. A new tool and way of working in and outside the classroom was introduced to the settings that were studied, leading to explorative research designs. Several complementary methods of gathering data were used, such as interviews, observation and questionnaires. One relatively novel approach to studying cases of mobile learning conducted for this research was the use of videos as a data source, including the parts of the learning scenarios that took place outside of the classroom. The practical challenges related to this approach are described in Wake, Guribye and Wasson (2011).

The choice to use video data was grounded by an interest in uncovering what the participants were accomplishing in practice when engaging with location-based games. Derry et al. (2010) argued that videos increase the “interactional detail that can be obtained and permanently stored for comprehensive analysis and reanalysis by multiple researchers” (p. 6). Koschmann, Stahl and Zemel (2006) pointed out that relevance and meaning, for example in learning environments, are not provided merely by their design, but rather something that participants need to work out in and through their interactions. Hemmings et al. (2000) explicated that this objective entails establishing how what they call the “educational character” (p. 224) of a

learning environment or activity "is visibly and accountably constituted as such" (p. 224) by the participants. To study learning then becomes "to discover within the recorded materials what the members are actually accomplishing (...) and are making relevant (…) through their interaction" (Koschmann, Stahl & Zemel, 2006, p. 7). It has become important to this research that what is actually accomplished or performed by the learners when operating mobile devices in the context that is set up should be established in studying the use of mobile, location-based games to facilitate learning processes. The understanding that results from such a study can in turn be used to re-inform the design of the learning environment.

How should learning activities using mobile techniques be designed to support innovative learning processes?

Citing the discrepancy between the high variance of new activities and practices arising in society following the advent of mobile devices, an increased availability of wireless Internet and the lack of a similar uptake in education, Milrad (2006) asked how innovative learning activities utilising mobile devices should be designed to appropriately make use of the opportunities afforded by mobile devices. He concluded that it resides in the interplay between learning theories, design and educational use, and that pedagogy and the learning theories "are the driving forces rather than the mobile technologies" (p. 31).

One aspect of how the notion of the meaningful design of learning scenarios was approached in this research was to include the teachers in the design process when the scenarios took place in a school. In short, teachers have a practical understanding of pedagogical, organisational and contextual constraints of activities going on in the classroom. For example, teachers in Norwegian education are aware of the demands on learning activities resulting from the most recent educational reform, how to carry out assessment, what the goals for learning are, etc. In other words, they know how to translate demands from policy documents to a workable pedagogical model down to the level of student and teacher activity. Another example of this is that classrooms are practical operating places associated with a set of limitations, constraints or

contingencies, such as time constraints, curriculum demands and other social constraints that must be taken into account in the design of all learning activities.

How can mobile devices be integrated with broader educational scenarios?

According to Hoppe (2006) this problem needs to be addressed for mobile learning to become sustainable in education, instead of a rapidly waxing and waning trend. The concept of integration in this context is complex, and Hoppe (2006) distinguished the different types of integration: *media integration* (conservation of results across different media in a learning setting), *process integration* (technical facilitation involving participants in different roles) and *knowledge integration* (broader structuring, systematisation and de-fragmentation of knowledge). In relation to the issue of knowledge fragmentation, one question highlighted by Hoppe (2006) is: "Do we have a problem with fragmented experience and fragmented learning activities in technology enhanced learning?" (p. 33); "If yes, is the fragmentation problem a particular challenge for mobile learning scenarios?" (p. 33).

This problem guided the design of the learning scenarios that were carried out in this research; perhaps in particular it was believed to be important to counter the effect of learning through the one-time experience of playing a game. The concrete problem was one of "how to make playing PB less of an isolated learning experience". For example, participants in Study 1 revealed that they would have found the game more engaging if they had known more of the history that the game is based on beforehand. When designing the first learning scenario to be carried out in a school, a "before – gaming – after" approach was chosen. Students were to create a presentation of a historical theme available through the game before playing it, using sources found online, and then continue to work on the presentation after the gaming session. For the final learning scenario a different, but related approach was chosen. Here, students were to use a wide array of sources in preparing games for each other. They would then use devices they brought with them in the gaming session to create different media products they would use to create presentations when returning to the classroom. This choice was made to increase students' interaction with the physical

environment, a lack of which was discovered in Study 3, and at the same time to avoid interfering with the gaming experience, or the experience of "flow" whilst gaming. In this way the issues of educational integration and the design of learning activities, through working in close conjunction with the teachers involved, was related to finding ways to discover and manifest opportunities for knowledge integration in the design of the learning activities in the scenarios.

3. Research Approach and Research Process

The research activities involved in the design, development and deployment of the PB game and the SILO system have been inspired by design-based research, a methodology that takes a practical approach to improving learning processes. A series of four empirical studies carried out from 2007 to 2011 focused on various aspects of using the PB game and SILO system. Study 1 focused on the usability aspects of the newly developed PB game, and methods of observation and interviews were used. Study 2 investigated how the game could be used in a classroom setting and be integrated with existing curriculum and learning practices. The methods that were used in this study were observation, interviews, questionnaires and an evaluation session with the teacher. Study 3 examined the interaction involved with playing the game, and relied exclusively on video of the game play as it unfolded. Study 4 explored how students could use the SILO system to create location-based games for each other. Video recordings, interviews and observation were utilised.

Chapter 3 is organised as follows: Section 3.1 presents the perspective and methodological approach of design-based research as it applies to technology enhanced learning. The overall goals and research questions for the studies that have been carried out are presented in Section 3.2. Section 3.3 presents the studies in chronological order with an emphasis on data collection techniques, participant characteristics, participant activities and the settings for the studies. Section 3.4 presents the data collection techniques that were employed in the studies, with particular attention paid to video-based research. Finally, a discussion of the credibility of the data is carried out in Section 3.5.

3.1 Design Experiments and Design-based Research

Ann Brown (1992) and Allan Collins (1992) established the concept of design experiments in two separate articles published in 1992 (Collins, Joseph & Bielaczyc, 2004). “Design experiments” was the term used by Brown (1992), while Collins

(1992) labelled his work as “design science”, although it was a design science for education. The more recent and persistent term is *design-based research* (Design-Based Research Collective, 2003). Accordingly, the following text will refer to the term design-based research. After a period with little discussion of the topic, design-based research has received a great increase in attention in recent years (Barab & Squire, 2004). Design-based research has, for instance, become a separate strand or topic in The Journal of the Learning Sciences.

Although design-based research is an emerging and still forming field (Collins, Joseph & Bielaczyc, 2004), with concurring debate about what constitutes the methodology (Barab & Squire, 2004), the definition by Wang and Hannafin (2005) is accepted as being relevant:

> “…a systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings, and leading to contextually-sensitive design principles and theories” (Wang & Hannafin, 2005, p. 6).

The Design-Based Research Collective identified five indicators of what constitutes solid design-based research (Design-Based Research Collective, 2003): 1) the design of learning environments and developing theories of learning is intertwined; 2) development and research take place through cycles of design, enactment, analysis and redesign; 3) research on designs lead to sharable theories that helps the communication of results; 4) research must account for how the design works in authentic settings — not only success or failures, but also interactions that increase the understanding of the learning issues involved; and 5) the development of these accounts relies on methods that can document processes of deployment or implementation to outcomes of interest.

Design-based research implies a pragmatic approach to educational innovations and improvement, and the utility and usefulness of designs are regarded as success criteria. A design scientist “attempts to engineer innovative educational environments

and simultaneously conducts experimental studies of that innovation" (Brown, 1992, p. 141). As a researcher he or she is thus not only responsible for establishing the effects of an intervention, but the researcher is also causing the effects (Barab & Squire, 2004). This duality of roles for the researcher, acting both as advocate of solutions and designs and neutral observer of the effects of these, is a central problem for researchers using a design-based research approach. Koschmann, Stahl and Zemel (2007) suggested that this could lead to the segregation of roles within design-based research groups.

Scientific experiments are often associated with the laboratory, and hypothesis-derived controlled exploration of the relationship between dependent and independent variables. Additionally, scientific experiments are often understood as being in contrast to naturalistic studies. Design-based research does not require laboratories in the traditional sense, however. Rather, effects of the intervention are studied in a real-life setting, as it is believed that cognition within a learner is inseparable from the context in which it occurs (Barab, 2006).

Cobb et al. (2003) stated that design experiments "entail both 'engineering' particular forms of learning and systematically studying those forms of learning within the context defined by the means of supporting them" (p. 9). Iteration of the design, implementation and evaluation are central and vital elements in design-based research (Brown, 1992). Collins, Joseph and Bielaczyc (2004) called this iteration "progressive refinement", which involves an initial testing of a design in the real world, after which constant revision of the design is carried through. With respect to longevity of the iterations, Brown (1992) described a design experiment that lasted for several years. Barab and Squire (2004) label a single iteration of the research process *boutique projects*.

Finally, an often-cited distinction between design-based research and related methodologies is the demand for theoretical generalisations. In formative evaluation, for instance, the research design stops after having described the effects on an intervention (Barab & Squire, 2004). In design-based research the aim is to generate

theoretical generalisations that are applicable to contexts other than where the experiment took place. This is a contradiction in most naturalistic studies, and Collins, Joseph and Bielaczyc (2004) argued that design-based research should be informed by solutions offered by other naturalistic and ethnographic research related to the demand for theoretical generalisations.

Koschmann, Stahl and Zemel (2007) argued that design-based research calls for fine-grained studies of educational *practices* and suggested ethnomethodology as a suitable way forward, as it is concerned with the "practical reasoning and procedures participants routinely employ in making sense of their own actions and the actions of others" (p. 136). The research methods associated with design-based research can be labelled ethnographic and qualitative (Barab & Squire, 2004; Colllins, Joseph & Bielaczyc, 2004), but in contrast to pure ethnographic research, design-based research goes beyond mere description, in that the research process has a stated goal of causing effects as well as describing them. The scientist can be both a researcher and educational practitioner. Collins (1992) identified eight characteristics of the approach to the design-based research process. There is an embracement of the value of studying learning as occurring in real-life settings. Instead of measuring a single variable, attention is given to several variables. Dedication is given to characterising the situation, as opposed to controlling variables. The design is flexible and open to revision. Social interaction occurs freely, rather than being controlled. Instead of testing hypotheses, a researcher should develop a profile that characterises the different elements of the design. Finally, the researcher is not an experimenter, but rather a participant in the experiment who attempts to involve others, such as students or teachers.

3.1.1 Design-based research and learning

The theory of learning and pedagogy implied in design-based research is not explicitly defined, but the dedication to creating designs where as many as possible of the contextual elements are planned for indicates a view of learning as a social phenomenon. Brown related her views to three of Dewey's tenets: readiness to learn,

discovery learning and the curriculum and society (Brown, 1992). *Readiness to learn* is a notion that the material portrayed should be related to both a learner's actual cognitive level and interest. Related to this, she described herself as adherent to the Vygotskyan concept of the zone of proximal development, which describes the level of a student's development as what the student is able to perform individually, compared to what the student is able to perform under the guidance of a more capable peer (Vygotsky, 1967). This view implies that one's competence level is a dynamic and manipulable phenomenon, rather than being an element that is gained in varying degrees of quantity that can be measured. When *discovery learning* is contrasted to didactic teaching, Brown takes a position in favour of guided discovery, where a teacher's role in guiding is to maintain a balance between interventions and letting learners discover. This implies a constructivist take on learning, where subject matter is something other than fixed. Brown's position related to *curriculum and society*, which is a notion that curriculum should be a continuation of social and community life, seems to emphasise interplay between knowledge inside and outside of a learner's community, where exposure to knowledge outside the learner's realm is considered equally important.

3.1.2 Influence on this research

Influenced by design-based research, a series of four empirical studies have been developed. Design of the studies has included the design of learning scenarios, including the game and technology used, the participants, such as teachers and students, and the activities that were carried out; and the design of the empirical study of the learning scenario, including research methods and questions.

Findings in the studies have been used to inform and refine the design of both tools and scenarios for future studies. Figure 3.1 provides a schematic overview of which tools were used in the different studies and in which cases the studies have lead to redesign of the tools and scenarios. The top two boxes represent the tools in question: PB and SILO. The green ovals represent the scenarios. The lower four boxes

represent each of the four studies. The blue arrows indicate which tools were used in the different studies. The brown arrows indicate that the results of each study resulted in redesign of the tools and/or learning scenario. Several alterations to the design of the game application were made after Study 1, and alterations to the scenario design were carried out after Study 3. The design of PB and SILO is covered in Chapter 4, and the iterations of the game design are covered in more detail in Section 4.3.3.

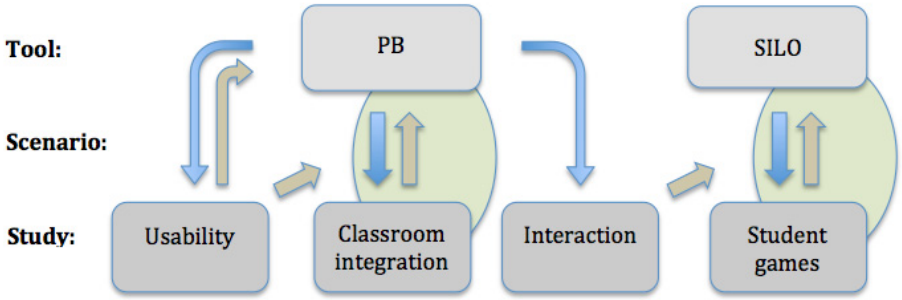

Figure 3.1. Iterations of the design through the studies

3.2 Overall Goals for the Empirical Studies

The aim for this research was to discover how mobile, location-based games could be used to facilitate learning. To that end, a mobile, location-based game was developed. In order to understand how this kind of game can support learning, the game has been studied in various settings to build knowledge about the kind of activities and social competencies involved with the engagement with location-based games and to be able to argue about the kind of learning practices involved. Several authors (e.g. Suthers, 2006; Koschmann et al., 2007; Hemmings et al., 2006) have argued that in order to discover learning, we must understand what participants do when they engage in activities that lead to learning. Much of the focus, thus, has neither been on the specific game or technology in itself, nor on the learning outcomes in terms of "increased knowledge" or "improved thinking" about a subject. Instead, the focus has

been on 1) what participants are doing when playing location-based games, and 2) how these activities can be incorporated into a pedagogical practice.

The overall research question that has guided the research is:

> *How can mobile, location-based games be used to facilitate learning?*

The overall research question was addressed through a series of four studies, each with a different perspective, combination of tools, participants and research methods. A brief and summarised outline of the studies that were carried out is provided here:

> *Study 1*: This study focused on the use of mobile, location-based technology in a collaborative gaming session and on how it was perceived by participants.
>
> *Study 2*: This study focused on how the location-based game PB could be integrated with classroom technologies and activities to provide a more lasting learning activity and experience.
>
> *Study 3*: This study focused on the gameplay of PB on a practical level, and more specifically, how participants engaged with the material presented in the game, how they used the resources available to them and how they communicated and coordinated between themselves to complete the game.
>
> *Study 4*: This study focused on and explored the educational potential of participants making location-based games for each other to learn history.

3.3 Chronological Account of the Research Methods Employed in the Studies

The overall approach to studying mobile, location-based games and learning adopted in this research did not begin with the study of an existing game. One had to be developed; consequently, a study of the first version of the game that focused on usability issues was a pertinent start to a more general study of location-based games and learning. Second, to study how the game can be integrated with classroom

activities, the game was integrated into a learning scenario carried out as part of the Memoz project. Third, a more detailed study of the interactional accomplishment of gameplay was undertaken. Finally, a study of students using the SILO system to make games for each other was carried out. Table 3.1 lists each study according to the year of study, participants, their activities, data sources and the research paper that documents the study.

Table 3.1: Timeline of the studies and methods used

Year of empirical study	Participants	Participant activity	Data sources	Research paper
2008	Focus group, aged 25–30, (N=9)	Collaboratively playing PB	Observation, semi-structured interview, questionnaire	RP1
2008	Upper secondary students, aged 18–19 and their teacher, (N=29)	Publication of historical material, playing PB	Observation, evaluation with teacher, questionnaire, artefacts	RP2
2009	Master students, aged 24–40, (N=12)	Collaboratively playing PB	Video	RP3
2010	Upper secondary students, aged 18–19 and their teacher, (N=28)	Creating location-based games, playing location-based games, creating media products	Video, interviews, artefacts	RP4

3.3.1 Participants and study settings

The participants and settings in the four studies varied. In Study 1 the nine participants were recruited from friends and family. The aim was to find out how the game worked and identify areas for possible improvement of the interface. In Study 2 the participants were a class of 29 students of an upper secondary institute of education in the Bergen area and their teacher. They took part in a scenario developed for the Memoz project (Hoem, 2009; Krüger et al., 2009). They researched the historical background for the PB game and published their different digital materials that they found in Memoz, which is a web-based tool for the spatial organisation and publishing of multi-media, developed for the research project also called Memoz. Having created an initial presentation of the material, they played PB, after which they revised and continued work on their presentations in Memoz. The teacher was also involved in the evaluation of the scenario, in terms of the activities and the tools of Memoz and PB.

In Study 3 nine of the 12 participants were students in a master's course on Computer Supported Co-operative Work at the Department for Information Science and Media Studies at the University of Bergen. Two participants were acquaintances, and one participant was a PhD student who filled in for a missing student. The gaming activity followed a lecture on tools in support of mobile collaboration and work and pervasive and ubiquitous technologies in general. The gaming experience was framed as a practical experience with a tool of this kind. The analytical focus of this study was on participants' interactions in the game, rather than learning itself, although the participants were aware that the game they played was designed with learning in mind.

In Study 4 the participants were a class of 27 students in upper secondary school and their teacher. The activities they were involved in were to research the history of Bergen, in groups, using a wide variety of sources, in order to find material to create a location-based game using the SILO system. Four pairs of corresponding groups were organised. Each group created a game for another group and then received a

game from the corresponding group in return. When playing the game, they were to record material based on what they experienced and use the material to create a presentation, using media of their own choice. They were graded on both their collaborative work with the game and the media product that was the outcome of the activity.

3.4 Data Collection

The approach to data collection used for this research is inspired by ethnography. Brewer (2000) defined ethnography as:

> "…the study of people in naturally occurring settings or 'field' by methods of data collection which capture their social meanings and ordinary activities, involving the researcher participating directly in the setting, in not also the activities, in order to collect data in a systematic manner" (Brewer, 2000, p. 6, cited in Silverman, 2011, p. 114).

Ethnography traditionally relies on qualitative and multiple methods such as observation, interviews and the collection of documents, pictures and audio-visual materials (Silverman, 2011). Dourish and Bell (2011) argued the case for ethnography in ubiquitous computing, as the material conditions for and social aspects within ubiquitous computing are highly intertwined. To Dourish and Bell (2011) ethnographic methods offer both a means by which the complexity of real-world settings, addressed by ubiquitous computing, can be comprehended and a toolbox of techniques for studying technology in naturally occurring settings. The methods used in this research were observation, interviews, surveys, the collection of artefacts and videos. The methods are presented in further detail below.

3.4.1 Data collection techniques used in the research

Following guidelines from design-based research, and inspired by ethnography, a multitude of data collection techniques were employed in the studies that are a part of

this thesis (see Table 3.1). Observation was used in all the studies, with the exception of Study 3. Activities have been observed as they unfolded in the classroom, but also outdoors as participants were playing the game. The observation that was carried out in the classrooms was largely participant, whilst a more hands-off approach was chosen whilst observing the gaming sessions because of the competitive context. In Studies 1 and 2, questionnaires were distributed to the participants (see Appendix A). The questionnaires in both studies had two parts. The first part was aimed at surveying mobile phone habits, e.g. with questions about what type of phones the participants owned and what they used them for, to gain knowledge about the general level of mobile phone experience. The second part of the questionnaire comprised questions about the actual gaming experience, the nature of the collaborative experience, whether the game was enjoyable, the ease of use and the level of understanding of the game itself. In both studies, the responses from the participants to the questionnaires were used to balance the observations and interviews.

Interviews were used in Study 4; all the students that took part in the scenario were interviewed in groups, in addition to the teacher (see Appendix B for the interview guides). In Study 2, an interview took the form of a lengthy, artefact-driven evaluation session with the teacher after the scenario had finished.

Evaluation of the artefacts that the students involved produced was carried out for Studies 2 and 4. In Study 2, the students produced a Memo, which is a web page in the Memoz environment, in which they presented their work with the historical themes related to PB. In Study 4, the students created two artefacts. The first was the location-based game. This was conserved in Microsoft Word format and included the names of the locations in the games, the text that described the locations, the missions for each location and the hints that were given on how to find it. Second, each group created a media product, which their teacher graded. The media products that had a digital form were copied and conserved.

3.4.2 Video as a data source in the study of gameplay and game creation

In order to achieve a detailed understanding of the social activities involved in playing the mobile games, video data were used in Studies 3 and 4. In Study 3, particular attention was given to how participants managed to complete their gameplay through their interactions, for example what kind of competencies were involved and how the game challenged them. In Study 4, videos were used to gain access to how they collaboratively created the location-based games, in addition to the actual gameplay.

Despite the potential to reveal details of social interaction in video recordings of everyday social activity, the use of videos is still relatively rare in the social sciences as a whole (Heath, Hindmarsh & Luff, 2010). Alfred Haddon is most frequently credited as the first who used film in fieldwork as part of the Torres Straight expedition in 1898 (Heath, Hindmarsh & Luff, 2010). Similar endeavours in time and theme are Baldwin Spencer and Francis Gillen's use of film in their studies of Australian Aborigines and Rudolf Pöch's field trips on New Guinea in the late 1800s and early 1900s. Within anthropology, there has been a substantial reliance on video and film, while there has been less interest in sociology (Heath, Hindmarsh & Luff, 2010).

Even though Derry et al. (2010) argued for disassociating video research with ethnography, conversation analysis or interaction analysis (Jordan & Henderson, 1995), the approach to video analysis taken here is inspired by ethnography and interaction analysis. This approach typically aims to uncover the resources people rely on in accomplishing their everyday activities and actions. In this endeavour video represents a technology that enables repeated, fine-grained scrutiny (Heath, Hindmarsh & Luff, 2010; Koschmann, Stahl & Zemel, 2010).

Within an ethnographic approach there is a dedication to understanding the actions and activities and the contexts in which they occur from the perspective of participants. This implies, amongst other things, that researchers should obtain a basic

level of understanding of participants' activities (Arminen, 2005), or become *vulgarly competent* (Lindwall & Lymer, 2005). For example, when studying the interactional organisation of gamers' playing of computer games, a researcher should obtain a basic understanding of the game that is being played, or when studying game play as part of a school-organised activity, a researcher should have a basic understanding of the school practices.

Another important aspect of taking the perspective of participants is inherent in the analytic focus of ethnographic video research. While close attention is paid to participants' situated talk and interaction (Francis & Hester, 2004), the focus is not on what the participants might think and feel. Rather it is on how the activity is interactionally accomplished in practice. That means how the talk, gestures and interaction feature in the participants' achievement of a certain outcome. Participants' utterances are taken at face value, rather than inferring different motives, thoughts and emotions from their utterances. Button and Sharrock (2009) phrased the analytic focus as: "What are the understandings that the parties to any social setting have, and how are their activities organized on the basis of those understandings?" (p. 34). Button and Sharrock further specified that these understandings are not general ideas or opinions about the state of things, but rather

> "…about their practical understandings and mastery, to be able to get things done, attention is on their grasp on how an activity gets done, on what they need to do to get it done once again, and on what they and others might need, in their various ways, to do together, accepting that in many settings this practical know-how might be heavily technical in character" (Button & Sharrock, p. 34).

Arminen (2005) labelled this process "utilization of the participants' own work" in order to achieve an intersubjectively available course of action on which the analysis is based. Analysis is not about participants' intentions or thought directly, but rather how she or he pays attention "to the features of talk-in-interaction oriented to by the

participants" (p. 70), and providing an account of these features compatible with the participants' own.

One aspect of using video recordings to study outdoor gaming in mobile, location-based games that developed over the course of this research is related to how to present the data in a way that helps the reader understand the participants' perspective. In interaction research it is common to present the transcripts on which the analysis is based. Arminen (2005) demonstrated how a detailed transcription, including for example intonations and emphasis in language, is important for the reader's understanding of the transcript. For the video material of outdoor gaming in this research, it was deemed insufficient to present detailed transcriptions of the speech, as non-verbal, physical actions and the environment itself featured critically in much of the interaction. For example, the non-verbal acts of gestures, orientation/gaze and coordinated bodily postures mediated the joint navigation of the physical space. Inspired by Bennerstedt and Linderoth's (2009) use of sequential art (McCloud, 1994) in the presentation of interaction analyses of online gaming, the presentation of the transcripts were accompanied by sequential pictures of the interaction, presented in a cartoon-like fashion, where the turns in the transcript were put in speech-bubbles. To develop this technique a step further, the aspects of the physical surroundings with which the participants are engaging should be included in a simple, but informing way.

3.4.3 Video-based research in mobile, location-based gaming

There are relatively few studies of location-based games that rely on video as a data source. However, two interesting studies have been identified. Tolmie, Crabtree, Rodden and Benford (2008) have carried out a study of the SMS-based game *Day Of The Figurines*, which utilised a range of qualitative data sources, including video footage of gameplay. The aim of the study was to cast light on how the players handled interruption in their everyday lives, thus contributing to the ongoing investigations within the field of computer supported cooperative work on how the

interruptions caused by emerging technologies are making users accountable in many different ways.

Benford et al. (2006) have carried out an ethnographically inspired study of the location-based game *CYSMN* (Can You See Me Now), which included making use of video in trying to capture the "workaday" (Benford et al., 2006, p. 107) character of the interaction involved with the game. Their studies reveal how participants deal with the technical uncertainties mainly arising from momentary lapses in technology, such as unavailability of GPS and Wi-Fi service, both of which the game depended on. In their study they focused on what kind of technical problems the players encountered, how the problems impacted the interactions, and the competencies involved in managing technical interruptions in the game. The competencies involved working knowledge of technologies, evidenced in how they tried to repair technical problems on the spot, and in the case of lapse in Wi-Fi availability, local knowledge of the geography, illustrated by how they moved in order to obtain a better signal.

3.5 Credibility of the Data

Silverman (2011) pointed out that the two central concepts in any discussion of data credibility are *reliability* and *validity*. From a conversation analyst perspective, Arminen (2005) defined reliability as "the potential repeatability of findings so that they are not accidental and idiosyncratic" (p. 67) and validity as "the accuracy of findings in terms of the avowed topic of research" (p. 67.). Reliability can be divided further into internal and external reliability, and validity can be divided into validity of single cases and extracts, and the validity of generalized findings (Arminen 2005).

Triangulation in qualitative research usually refers to combining multiple sources, such as theories, methods, observers and empirical materials (Silverman, 2011) to solidify the validity of the research. The approach to triangulation taken for this research lies inherent in the reliance on several methods for data collection and empirical sources for each study. For example, in Study 1, an open-ended, collective face-to-face interview session was combined with a questionnaire completed

individually by each participant, in an attempt to capture views and opinions that may not have been voiced in the face-to-face interview session. In Study 4, observation was combined with semi-structured interviews with the participating groups and their teacher, which allowed a grounded frame of reference to be developed for carrying out the interviews. The exception to relying on a varied set of data sources was Study 3, which relied on video exclusively. This choice followed from the analytical perspective inherent in focusing on the interactions, as discussed in Section 3.4.2.

Transparency in the data collection and analysis process is a way to ensure the reliability of data, and the goal is to document the research procedure openly and thoroughly (Silverman, 2011). Transparency in the data handling increases the replicability of the research, or whether other researchers could repeat the process in the future and come up with the same results and interpretations. The documentation of this research process follows the dissemination of the four studies that were carried out. This means that an account of which data were collected for each study, how they were cultivated or processed, and which kind of questions the material was used to answer is available in each of the research papers corresponding to each study.

4. The Design of SILO and Premierløitnant Bielke

Chapter 4 takes an historical approach to dealing with the technological background and context for describing the technology that has been central to the work committed for this research. An account of the origins and ideas of ubiquitous computing is used as a starting point. Then an overview of location-based games designed for education, with an emphasis on bringing forward the diversity and nature of the games with respect to collaboration and learning domains, rather than being an exhaustive review of all the location-based games that exist is given. Finally, the authoring tool and game that have been designed, implemented, deployed and re-designed for this research is presented, including how the technology has evolved during the course of the studies.

4.1 Ubiquitous Computing

Mobile, location-based games are emerging against the backdrop of ubiquitous computing (Wake, Guribye & Wasson, 2011). Mark Weiser coined the term ubiquitous computing, and the earliest printed reference is available in an article in Scientific American in 1991. Weiser (1991) contrasted ubiquitous computing with desktop computing, which he believed was only a transitional phase in computing. Hence, ubiquitous computing refers to technology and computer *use* that is not limited to taking place in front of a screen connected to a stationary computer (Wake, Guribye & Wasson, 2011.). But Weiser (1991) was not only writing about taking computers outside; his vision was that information technology use would vanish from our conscience, and support activities from the background, allowing users to focus on their objectives and goals, rather than on the technology itself. This was the basic component in his vision of an era of calm computing. He also contrasted ubiquitous computing to virtual reality, which he characterised as "focusing an enormous apparatus on simulating the world" (Weiser 1991, p. 94) instead of attempting to invisibly enhance the world as it already exists. Practically, he worked on developing

a set of devices of different sizes that he called tabs, pads and boards, analogous to calculators, as well as A4 paper and chalkboards, respectively, connected through wireless and infrared technology.

Weiser's (1991) idea of contrasting virtual reality to a map and ubiquitous computing to the territory is compelling, yet it may be argued that the idea of the technology disappearing from the conscience of a user is something that may well happen to a user of stationary computing devices also, after a process of learning. It should also be assumed that the office or home with a stationary computer is also a place, or location, just like somewhere outside, but perhaps with a different nature. Rogers (2006) remarked that Weiser's vision of calm computing largely has not materialised, and suggests that instead of supporting activities from the background, ubiquitous systems could just as well be used to facilitate experiences that are engaging. Paul Dourish (2004) considered a similar historical timeline in computing as Weiser, but his focus was rather on the interaction. Considering the historical development in human interaction with computers, Dourish (2004) proposed a historical timeline that can be described as beginning with and moving on from *electrical* interaction, through *symbolic* and *textual* to *graphical* interaction, which is currently the most dominant and widespread form of interaction.

Electrical interaction is associated with the earliest versions of computers, including analogue computers, where the configuration of the computer drew on knowledge about electrical circuits (Dourish, 2004). *Symbolic interaction* was made possible by the introduction of programming systems such as assemblers and programming languages, and interaction with computers became a matter of manipulating symbolic representations of the computer operation, increasing the range of human skills relevant to interaction. *Textual interaction* is distinguished from symbolic interaction by establishing a notion of interactivity for users, or a sense of having a dialogue with computers, in the sense that from textual inputs, computers produce a response. *Graphical interaction* takes place in a two-dimensional space, opening up new dimensions in interaction compared to textual interaction, for example the direct manipulation of information objects (Dourish, 2004). Dourish made the point that

graphical interaction makes it possible to use an even wider range of human skills and abilities in interaction with computers, for example the ability to operate and reason in a space and making use of visual metaphors for information management.

The main line of reasoning in portraying the history of interaction in this particular way is that there has been a gradual increase in the range of human skills and abilities that are relevant to human-computer interaction (Dourish, 2004). Whilst the approach implicit in graphical interaction can be described as making use of graphical metaphors to make computing more accessible, ubiquitous computing, or to use Dourish's label "*tangible computing*" (Dourish, 2004, p. 15), opens for the perspective of "drawing on *the way the everyday world works* or, perhaps more accurately, *the ways we experience the everyday world*" (Dourish, 2004, p. 17, italics in original.). This perspective is closely tied to the concept of embodiment, which highlights that "things are embedded in the world" (Dourish, 2004, p.18) and that human thought and activity has a situated nature, rather than something that humans relate to in a mere logical and rational manner. The concept of embodiment, in contrast to a cognitivist perspective, is relevant to information systems design because it emphasises how interactions are tightly connected with the settings in which they occur. It also implies a turn towards considering activities and artefacts in concrete terms rather than abstract ones, and that through being embedded in the world, the artefacts assume a pluralistic character — they can be used for many things and mean different things to different people at different times (Dourish, 2004).

The developments that have made mobile location-based games possible are related to the concepts of ubiquitous computing in several ways — first and foremost in the sense that computation is distanced from both the actual desktop and the desktop metaphor. Instead, aspects of the physical world are augmented with information, displayed on small, portable computers such as mobile phones, making the information system one that includes electronic processors, memory, and physical aspects of the real world.

4.2 Mobile, Location-based Games

This section provides an overview of location-based games and how they can be used to facilitate learning. There is a plethora of mobile, location-based games, and those that have been developed for learning and education will be reviewed more closely. The review will focus on the technology on which the games are based, whether and how the game involves collaboration and the learning goals for the game. It will also focus on *games*, omitting for example mobile, location-based technologies that are more associated with non-gaming activities, such as Ambient Wood (Price & Rogers, 2004; Rogers, et al., 2004, Rogers, et al., 2005), which uses mobile, pervasive tools to let students interact with a forest, or EagleEye (Jong, Luk & Lee, 2012), which is a GPS-based system for enhancing student learning during field trips by increasing scaffolds and opportunities for collaboration. Likewise, location-based games that are not explicitly designed with learning or education in mind, such as Can You See Me Now? (Benford et al., 2006) or Capture the Flag (Cheok, Sreekumar, Lei & Thang, 2006), are omitted.

In the literature there are many terms used to describe games that are available on portable devices, including pervasive games, ubiquitous games, augmented reality games, alternate reality games and mobile games. In this thesis the term *mobile, location-based game* is adopted. This term is chosen because *mobile* highlights how game players rely on their mobility in their interaction with the game, and *location-based* emphasises how the appearance and characteristics of different physical locations are part of the game constellation.

Visions of Sara is a game Ejsing-Duun (2011) developed as part of her PhD research, in which the goal is to explore the town of Odense, Denmark. The setting for the game is 16th century Odense, where the players take the role of Sara, who is being haunted by a murdered nun. In taking part in game play, participants are guided along a trail of different visions that Sara had in 16th century Odense, creating a link between the past, the present and place. Much like with PB, the goal is to allow players to experience an everyday space in a new way. It is created on the DJEEO

platform (http://www.djeeo.dk/). *Visions of Sara* has a *control room – field agent* structure, similar to Frequency 1550 described below. A *base agent* operating from a control room guides the *field agent* around Odense. The field agent uses a GPS tracking device, a mobile phone for communication and a folder containing information about the locations in the game. The field agents do not use a device with a screen, as a design decision was made to increase the focus on the environment. The base agent sees the location of the field agent on a map displayed on a computer and has the task of guiding the field agent towards a series of flags, also displayed on the map. Between the flags they collaboratively solve *route tasks* and *location tasks,* and points are awarded for finding the flag/location and solving tasks that are presented and responded to in text at each location.

In his doctoral dissertation Lonsdale (2011) provided an account of the use of mobile and game technologies to support situated, experiential and enquiry learning in the field. The main outcomes of the thesis are empirically based evaluations of how games can structure and support learning outside the classroom, a software framework for building and deploying mobile learning activities and the development of a grounded theory of mobile game-based field learning. Two software items was created as part of his research, *PaSAT* (Participatory Simulation Authoring Toolkit) and *BuildIt*. *PaSAT* is a toolkit for creating mobile games, developed on the Microsoft .NET platform, and represents a combination of an authoring toolkit, a game server and a mobile client to be used on PDAs in the field. Using the authoring toolkit, game designers are able to assemble locations on a map with game events and game states. The game server facilitates data exchange between the game server and the mobile clients, in addition to keeping the game states, while the mobile clients provide an interface to the game players. The information that is displayed to the users is a map, including the users' position, in addition to portraying the game status and available interaction options. It was a design requirement that non-technical users should be able to use the game-authoring interface.

BuildIt (Lonsdale, 2011) is a situated mobile game for supporting outdoor enquiry learning that was developed using PaSAT. The goal of the game is to find suitable

sites on a school ground for three new buildings, and the participants have fixed budgets for costs and risks that cannot be exceeded. Buildings invoke different costs and risks depending on where they are placed. Participants play the game by moving around the school ground, taking *Estimates* and *Building.* Taking an estimate is obtaining information about what the costs and risks will be for placing a building in a particular place before building it, and a total of six estimates are available. The game is won if the participants are able to place three buildings on the school site without exceeding budgets for risks and costs, and the game is lost if either budget is exceeded.

Environmental Detectives (Klopfer, Squire & Jenkins, 2002; Klopfer & Squire, 2003; Klopfer, Perry, Squire & Jan, 2005), implemented on GPS-enabled location-aware PDAs, is a multi-player game where late high school and early college-aged students act as detectives in charge of investigating a toxic spill in a real environment, and it was designed for students to learn science. Acting as teams of scientists, students conduct readings from the environment using simulated instruments. By interviewing experts, interpreting relevant background information provided in the game and taking pictures to support their findings, they are to locate the source of the pollution and come up with suggestions for remedying the situation within a given time frame. The students operate in teams, and the game is designed in such a way that collaboration in the form of task division is necessary, promoting interdependence within the participants in the teams.

Mad City Mystery (Squire & Jan, 2007), built on the same platform as Environmental Detectives, is a GPS-enabled game where students investigate an untimely death, caused either by murder, suicide or contamination by toxic chemicals found in the region. It is designed to last between 90 and 120 minutes and relies on text, documents and multimedia. The game begins with players reading about the death of the fictional character Ivan Illyich, where the police report states that he died whilst fishing in Lake Mendota. At the same time the game players are informed that he experienced great health problems in the last months of his life, including heavy drinking and gaining weight. The game players, acting as friends of Ivan, have to

establish the cause of his death. Gameplay involves interviews with virtual characters, the gathering of data samples from the environment and the examination of government documents. The educational purpose is tied to science learning, and in particular the development of scientific argumentation skills through the investigation. The game is played in teams, and competition between teams is optional. The game is designed so that there are several possible answers to Ivan's death, rather than one single cause, and the idea is to help students develop complex problem understanding.

Savannah (Facer et al., 2004; Benford et al., 2004, Benford et al., 2005), supported by GPS-enabled PDAs connected to a server through WiFi, has a two-part game space — the "Savannah" and the "Den". Gameplay is about first exploring the opportunities and dangers for survival on the "Savannah" for a pride of lions, which can then be reflected upon indoors in the "Den", where more resources can be accessed, and strategies for survival can be developed by the players. The "Savannah: is a 100x50 meter large outdoors field, divided in different zones, which contain different wildlife types and biotopes. Depending on the zone, the game provides different savannah-related output in the form of sounds, still images, and footprints belonging to different animals. The indoor "Den" contains an interactive whiteboard with a map of the "Savannah" and energy bars for each of the "lions". Gameplay is about surviving as lions on the "Savannah". Threats to survival are other animals, such as elephants and water buffalos, humans and bush fires. Opportunities for survival are hunting for suitable animals, finding water and shade, and killing the cubs of other prides. The players have to learn the optimal balance between hunting, resting and drinking, in order to maintain their energy levels. The game has a collaborative aspect in that players have to decide how to collaborate to achieve the game objectives.

CatchBob! (Nova, Girardin & Dillenbourg, 2005a; Nova, Girardin & Dillenbourg, 2005b, Girardin & Nova, 2006) is a game designed to investigate the collaborative aspects of mobile games and as such does not have any direct learning goals in a curricular sense. Gameplay is conducted in teams of three, and the goal is to surround a virtual object within an 850x510 meters game space on the campus of Ecole

Polytechnique Federale in Lausanne, Switzerland with a triangle, where each corner is represented by a participant or player's position. It is played using tablet PCs, connected through Wi-Fi to a server running the game, and a player's position is determined through Wi-Fi triangulation. A users' proximity to the object is indicated by a progress bar, the position of the other players are displayed and can be updated by pressing a refresh button. Players are also able to annotate the map whilst playing. When players are near the object they are to find, the triangle that they have to form shows up on the map, and they have to adjust to the triangle to complete the game. The game has been designed so that it is possible to remove the indicators displaying the other players' locations to investigate the effect of location awareness on collaborative gameplay in location-based games, or how spatial information affects collaborative processes.

Frequency 1550 (Admiraal, Raessens, & van Zeijts, 2007; Akkerman, Admiraal & Huizenga, 2009; Huizenga, Admiraal, & Akkerman, 2009), or "*Frequentie 1550*" in Dutch, is a game where players are introduced to medieval Amsterdam. They play the role of pilgrims in search of gaining citizenship to Amsterdam and interact with the bailiff of the city, who will grant them citizenship if they are able to find the Holy Host, an artefact of historical significance to Amsterdam. The game is a competition between teams, as the team who first gains 366 points, (or days, referring to the number of days historically a person needed to live within the city walls to achieve citizenship), wins the game. Teams consisting of a minimum of four players are divided in two, with two players forming a headquarters team in an indoor headquarters location, and the other two forming a city team, playing outdoors. Supplied with smartphones, the two pairs can communicate via video calls, and connect to the game server via mobile broadband. The headquarters team is supplied with an additional internet-connected PC, displaying a map of medieval Amsterdam, and a map of current Amsterdam is used to guide the city team. The city team has one phone for video calls and one phone displaying a map of medieval Amsterdam, and their position is indicated on the map. The headquarters team sends assignments in the form of pre-recorded video clips featuring medieval characters to the city team and uses the PC to find information to help the pair on the street. The characters in

the video clip reveal, a little at a time, what happened to the Holy Host, leaving it to the players to piece together the whole story. The city team completes assignments and sends them back to the headquarters in the form of videos and pictures.

In *MobileMath* (Wijers, Jonker & Kerstens, 2008; Wijers, Jonker & Drijvers, 2010), two to eight teams of four players compete to create geometrical shapes such as squares, rectangles and parallelograms on a predefined outside field. The size of the playing field and the duration of the game are set by the person who first starts the game, to which the other participants then subscribe. Using a GPS-enabled mobile phone, players see themselves moving in real time as dots; there is a distinguishing colour for each team displayed on an underlying map of the playing field. The teams first decide the starting point for their shape and upload their position to a server. A dotted line then follows the teams' movements from the position until they decide where the second corner of their shape is and upload that. The dotted line then becomes solid, and a new dotted line follows each team's movements from the second position. When the fourth and final position is determined and uploaded, the game server decides whether the shape, with a margin of 10 meters, is completed or not. If a shape is complete, it appears in each team's colours on the map of all the teams, and temporarily occupies the space on the map, thereby potentially hindering the other teams from using that space. If it is incorrectly completed, the shape disappears. Points are awarded for the size of the shape, multiplied with a factor indicating the complexity of construction of the shape (2x for a square, 1.5x for a rectangle, 1x for a parallelogram). Points are also awarded for deconstructing the shapes of other teams. Deconstruction is accomplished by starting in a corner of another team's shape, then finding out where the middle of an equal, but mirrored version of the shape would be, walking to that position and uploading the team's position to the game server. The team with the most points when the game is finished wins.

Treasure Hunt (Spikol & Milrad, 2008), or "*Skattjakt*" in Swedish, inspired by treasure hunt activities and the sport of orienteering, is a game about solving a mystery regarding a castle on the campus of Växsjö University in Sweden. The goal

of the game is to promote physical activity and learn local history. Gameplay is conducted using mobile phones displaying an interactive map, connected to a game server that provides the game's logic. The aim is to help the ghost of Anna Koskull to solve a mystery about her lost husband's obsession with numbers and untimely death, and the ghost has only one available day each century to solve the mystery — the day that the players are playing the game. Gameplay involves finding a number of locations, at which they are to collaboratively solve puzzles, decode numbers and find landmarks. Three different game modes can be displayed on the screen — map mode, ghost mode (which provides audio cues) and question mode.

Table 4.1 summarises the reviewed games. The column "Learning domain" is about what the players of the game are meant to learn. All of the games reviewed are intended to be played by several players simultaneously. The nature of the multi-playerness can, however, take on several different meanings, intentions and practical organisation. This is reflected in the "Collaborative" column. The "Place-specific" column indicates whether there is an actual location where the game needs to be played; for example some location-based games are played in a specific town or part of a town and use specific visual characteristics of that place as part of the game design. Other games rely on position and positioning technology, but could in principle be played anywhere, as it is the players' relative positions to each other, or positions in the game space, that are relevant to game play. The "Devices" column indicates the main features of the technological infrastructure on which the games rely. The last row of the table identifies the characteristics of PB, which are described in Section 4.4.

Table 4.1. Overview of location-based games described in this review

Name	**Learning domain**	**Collaborative**	**Place-specific**	**Devices**
Environmental Detectives	Science	Group-internal collaboration	Yes	PDA/GPS
Mad City Mystery	Science, argumentation/ reasoning	Group-internal collaboration	Yes	PDA/GPS
Savannah	Ecological systems	Negotiation, group-internal collaboration	No	PDA/GPS, Wi-Fi
CatchBob!	Collaboration	Experimental, cooperative	No	Tablet PC, Wi-Fi
Frequency1550	History	Internal collaboration & cooperation, external competition	Yes	Smartphone, GPS, UMTS, PC
MobileMath	Mathematics/ geometry	Internal coordination, external competition	No	Mobile phone, GPS
Treasure Hunt	History, physical activity	Internal collaboration	Yes	Mobile phone
Visions of Sara	History/ geography	Collaborative/ cooperative	Yes	Mobile phone, GPS, PC
BuildIt!	Scientific enquiry	Collaborative	Yes	PDA, GPS
Premier-løitnant Bielke	**History**	**Internal collaboration, external competition**	**Yes**	**Mobile phone, GPS**

4.3 SILO – A Tool for Authoring Location-based Games

SILO[1] (see Figures 4.1 to 4.4) is a two-layered technological infrastructure for authoring and playing location-based games that build on MOTEL (Baggetun, 2009). One layer is a web-based authoring tool for creating location-based games, and the other is an application that interprets data created in the authoring tool and contains the game logic. The authoring tool is written in Django (http://www.djangoproject.com), which is an open-source framework originally designed for developing database-driven news-related websites in Python (http://www.python.org). Games are created in SILO in basically the same manner as annotating a map with text and icons, by clicking on the map and adding the text and icons, where the text is the game narrative or storyline. When the game is complete, it saves all the data in a zip-file, which can be downloaded and transferred to a phone. The phone application, written in Python for Symbian 6.0 (PyS60), then installs the data, used by the game logic to create a game. PyS60 is a version of Python customized to work for mobile phones running on Symbian (Scheible & Tuulos, 2007). SILO is currently being developed for Android and iOS.

Several location-based games authoring or editing tools bearing resemblance to SILO have begun to become available, both as a part of research projects, and as publicly available software. Examples of these tools are:

- 7-scenes (http://7scenes.com/)
- Arisgames (http://arisgames.org/)
- COLLAGE (http://www.celekt.info/projects/show/14)

[1] The technology developed for the studies that are a part of this thesis is called SILO, which is a continuation of the work conducted by Rune Baggetun on the MOTEL project, which was about developing mobile, digital tools for supporting biologists working in the field. SILO was programmed by Bjørge Næss, at InterMedia, Uni Research.

- DJEEO (http://www.djeeo.dk/)
- EagleEye (http://caite.fed.cuhk.edu.hk/ee/resources.php)
- GamesAtelier (http://www.waag.org/project/gamesatelier)
- Radford Outdoor Augmented Reality (ROAR) (http://gameslab.radford.edu/ROAR/)
- Taleblazer (http://www.mitstep.org/projects/taleblazer).

By dividing the authoring tool and the application running on the phone, SILO can support the rapid development of location-based games using the same technological infrastructure. This aspect of the functionality was utilized in Study 4, where a class of students created games for each other as part of their history lessons.

Figure 4.1 shows the SILO authoring interface. By clicking on “Add” game in the screen visible in Figure 4.1, a user opens the game creation dialogue, as seen in Figure 4.2. The user can add a name for the game, start and stop times and participating groups and select the zoom level and area covered on the map. The choices made during the authoring will appear on the mobile phone. The map technology that is used is openstreetmap.org (http://www.openstreetmap.org), which is an open-source, community based mapping project that covers the entire world. Participants supply GPS-tracks to the openstreetmap.org editor, tag the tracks with different properties (such as street, water, building and so on) and upload the data to create the map. At the time when SILO and the game Premierløitnant Bielke were developed, the area of Sandviken, where Premierløitnant Bielke takes place, was very scarcely mapped. Thus, the group of developers involved carried out the mapping of this area.

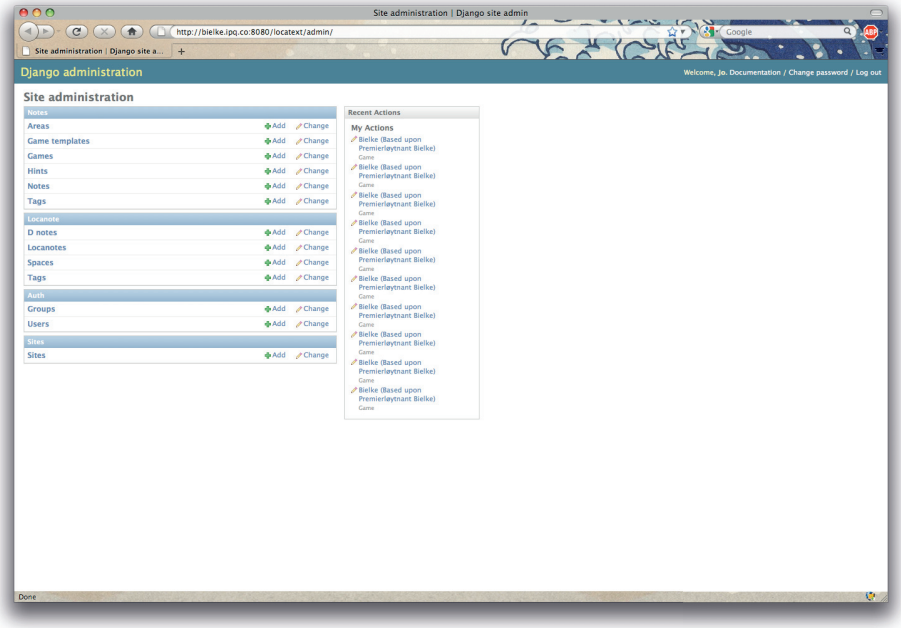

Figure 4.1: SILO

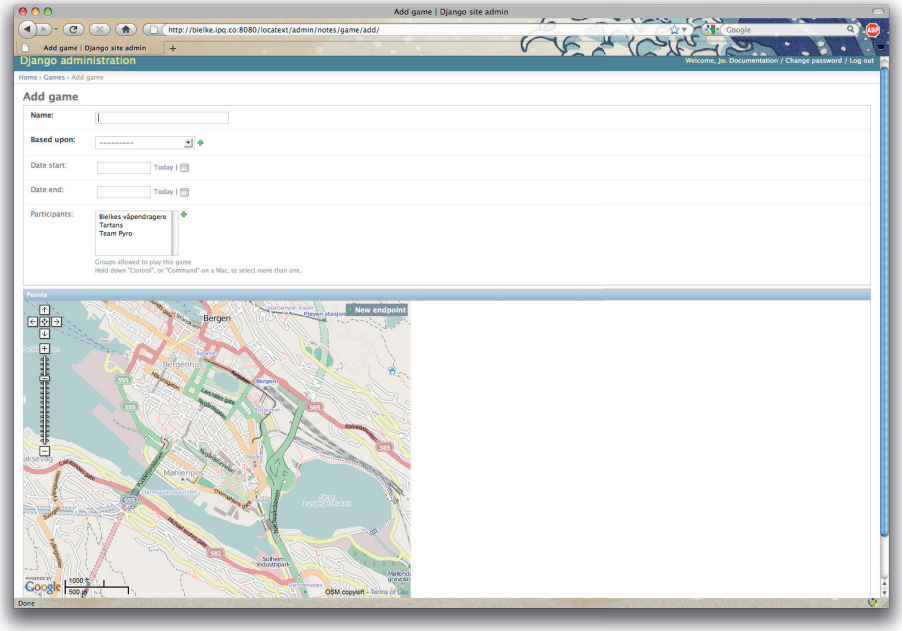

Figure 4.2: SILO game authoring interface

4.3.1 Creating a game

To create a game narrative (see Figure 4.3), a user first clicks on the location on the map where he or she would like the game to start. Several new menus and windows will then open next to the map. First, the user must add a name for the location clicked and add the text that he or she wants the game player to read at this location. Typically it will contain information about the location and about how to find the next location. The user can also upload an icon that describes the location. Icons are used in a progression bar displayed on the phone to indicate how many locations in the game the user has found and how many are left; see Figure 4.5. GPS data for the location is added automatically when clicking the map. The user can also add a number of hints on how to find each location because when playing the game, the player needs to visit all the locations in the game in the correct order. The order between the locations in the game, indicated by the blue line on the map in Figure 4.3, is created automatically when two or more locations are created in a game. The order between the locations can be altered easily.

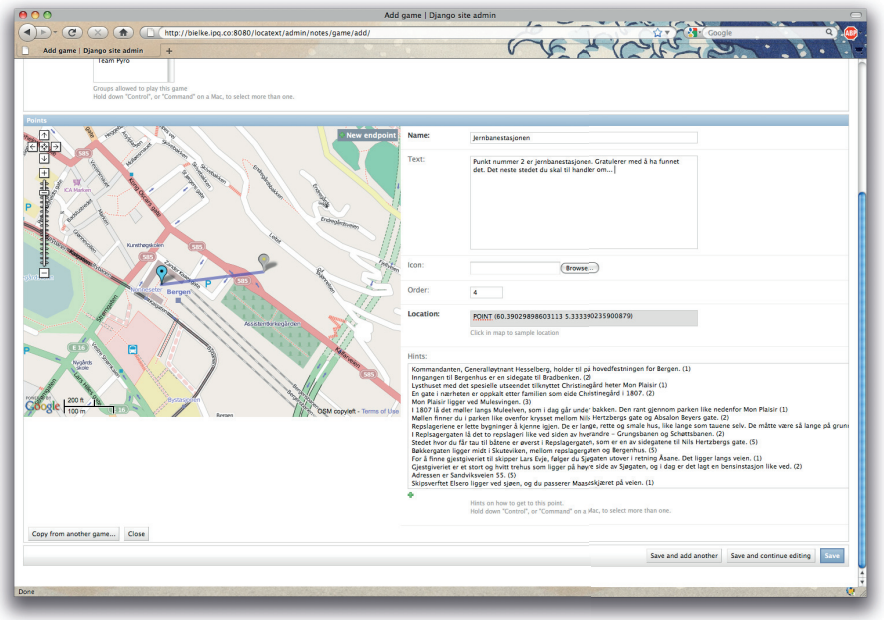

Figure 4.3: Creating a game using SILO

A game is saved by clicking the blue “save” button to the bottom right of the screen in Figure 4.3. Saving the game (see Figure 4.4) adds it to the list of games available in SILO. Two steps are required to install the game on a phone. First, the link belonging to the game in question, seen on the right side of the screen in Figure 4.4, is clicked, and a user is offered to save a GCF file (**g**ame **c**ache **f**ile, archive format) on their computer. This file can then be transferred to the phone, for example by Bluetooth or a cable. The GCF file contains all the textual data as a string, including the GPS-position, the game narrative and the hints for each location. The file also includes the icons and the map of the area to be displayed on the phone.

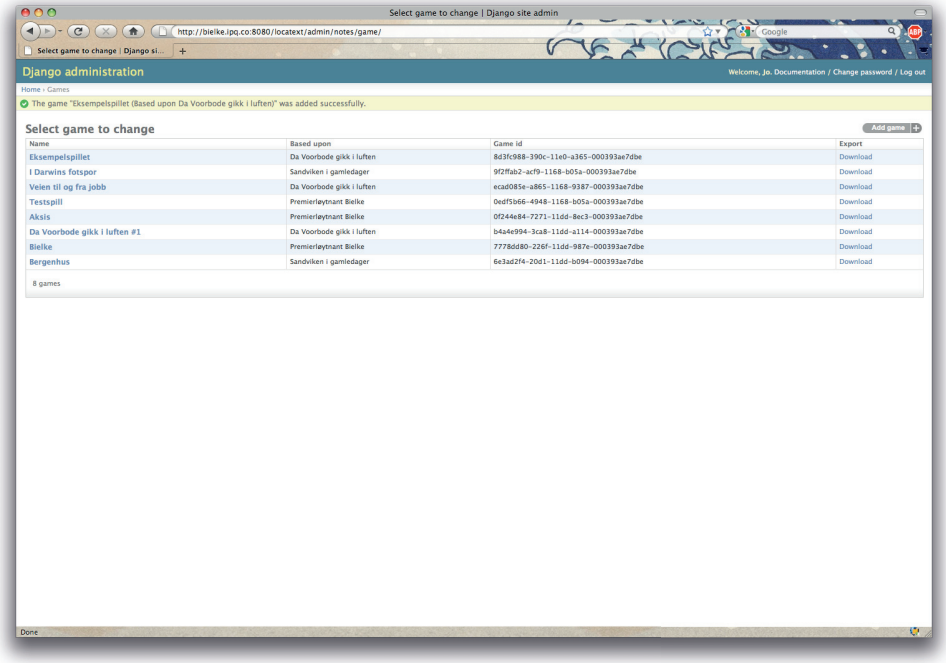

Figure 4.4: Downloading games from SILO

When the game application is opened on a phone, it first checks for new available game data. If it finds new data, it will install the game. If no new game data are found, the application will display a list of already-installed games and let the user choose which of them to play.

The game application will then display a map, the icon or progression bar on the left side of the screen and a number displaying the distance to the next location in the upper right corner; see Figure 4.5. The number is decided by GPS, either internal to the phone or an external GPS unit connected to the phone. The game application will also create all the locations, with a margin of error zone of 30 meters around the GPS location. A margin of error is necessary for several reasons: first, the locations are created through clicking on a map, which is easy to do and fairly accurate, but not accurate to the meter. Second, GPS data are subject to a number of error sources, depending for example of number of satellites available and clarity of the signal, determined by weather. Third, the presence of several buildings can be an error source. The size of the margin of error, however, has been subject of discussion in several of the studies.

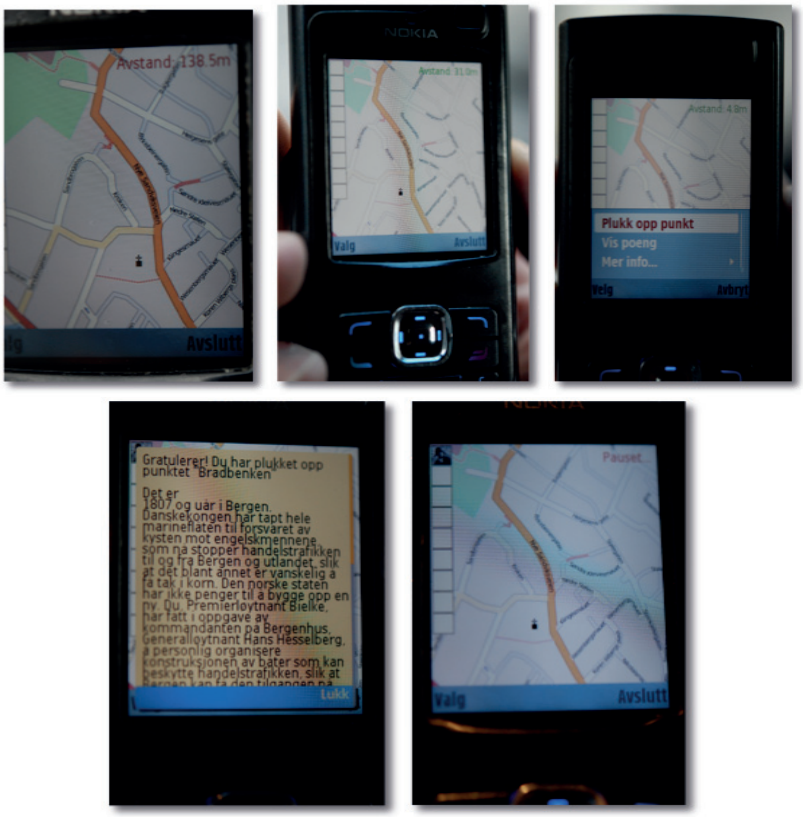

Figure 4.5: Interaction with the phone application

4.3.2 Playing a game

The goal of SILO games is to find all the locations and accumulate the least number of points. The time spent and the number of hints used adds to the total number of points gained in the game, and the team with the lowest score wins. SILO games can be played individually or in teams. In teams, players share a phone. One potential pedagogical advantage to organising game play in teams is that sharing a phone facilitates discussion within groups.

When the game begins the application displays a map, with the icons on the left side and the distance to the next location in red numbers in the top right corner; see Figure 4.5. The numbers will decrease or increase dependent on whether a phone is moving toward or away from the next location in the itinerary. When the phone is within 30 meters, the numbers turn green, as can be seen in Figure 4.5. The user then accesses the text for the location by using the menu system available on the bottom of the screen, as seen in Figure 4.6. The text is then displayed as an overlay of the map. When the text is closed, the icon for the location is displayed in the progression bar and the game pauses. This is to allow the team time to discuss what to do next, without loosing points in the game.

To help the players find locations they can opt to use hints, which they can use to lead them in the right direction. The number of hints available depends on the game in question, but for the PB game, described in Section 4.4 below, a total of three hints were available for each location. It was decided that the use of hints adds points to the score, in order to lead the group towards relying on discussion, rather than using hints. Each hint used adds an increasing number of points to the total score, and the game designer decides the number of points added to the total score for each hint. Hints are accessed through the menu system on the bottom of the screen (see Figure 4.6).

Figure 4.6: Accessing hints from the gaming application

4.3.3 Design iterations

The design of the SILO system has been informed by several studies. Alterations to the design, applying mostly to the phone application, were carried out after the first field trials. After Study 1, a “save data” file was added to make it possible to render data from the gaming session and review them upon conclusion of the game. The pause functionality was also added after Study 1, as it was found that the game was too centred around running from place to place in order to win the game, which contradicted the goal of facilitating observation of and reflection on the locations. A tracker, displaying a phone's position and tracking previous movement, was added after Study 2, in order to make the map more interesting. Sound, in the form of a trumpet fanfare played when a location was found, was also added.

4.4 Premierløitnant Bielke

This section provides an account of the game called Premierløitnant Bielke (PB) that was created using the SILO system and designed for teaching and learning history. The goal of PB is to find locations relevant for the production of gunboats in the Bergen town area of Sandviken in the early 1800s. The content was developed by reviewing different historical sources, such as the diary of Premierløitnant Bielke, which he wrote when he was in Bergen, but also through discussion with the City

Inspectorate for the Protection of Ancient Buildings (*Byantikvaren i Bergen* in Norwegian).

The main idea behind the game is to combine the locations that were relevant for the production of gunboats in Sandviken, Bergen, with a storyline, or set of quests, about the same locations in the form of a game to potentially provide an immersive and novel way of learning history. The constellation of these factors can be labelled an *ad hoc* museum (Wake & Baggetun, 2009). Around this time Bergen was a maritime trade hub, with most of its activities connected to shipping and trade via sea. Some of the different vocations that were relevant to support this are brought forward in the game and tied to actual locations in the local surroundings to students from Bergen.

The historical context for the game is Bergen, Norway during the Napoleonic Wars. Norway took part in this war by default, as Great Britain annexed the rather substantial navy fleet belonging to the Danish-Norwegian union because they did not want Napoleon to be able to use it. After a bombardment of Copenhagen, the Danish king surrendered the fleet to the British. This caused a period of distress in Bergen, as the war led Great Britain to block trade routes via the sea. Due to the resulting scarcity of food and supplies, the citizens of Bergen needed to amend the situation and decided to build small, rowed gunboats to defend merchant ships against the larger British frigates. This took place all around the coast of southern Norway. The drawings for the boats came from Sweden. After having built several of the gunboats, the citizens of Bergen, under the leadership of Premierløitnant Bielke in 1808, used them, and favourable weather conditions, to defeat and chase away a British frigate named Tartar, in what has afterwards been called the “Battle of Alvøen”. The rowed gunboats were equipped with one cannon each, and the British frigate was equipped with 37. The day the battle took place, however, there was vey little wind, leaving Tartar largely immobile.

After the first field trial of PB with users (Study 1), it emerged from the data that the participants would find the game much more motivating and exiting if they had known the historical context before playing the game. Thus, a briefing session

including a presentation of the historical context was provided before the gaming session in the following field trial (Study 2).

Figure 4.7: Selected locations in PB

The first location that the players have to find is the residence of the historical figure of the commandant of Bergenhus, General Lieutenant Hans Hesselberg, to receive the drawings for the boat. The text that they receive contains the following (translated from Norwegian): “The year is 1807, and there is famine in Bergen. The Danish King has surrendered the naval fleet for defence of the coast to the British, who are now blocking trade via the sea, making it difficult to obtain grain. The King doesn’t have the means to rebuild the fleet. The commandant of Bergenhus Fortress, General Hans Hesselberg, has assigned you, Premierløitnant Bielke, to personally organise the construction of gunboats to protect the merchant ships, so that trade can continue. Don’t despair, everything you need to build the boats is located in Sandviken, but you have to find the places by yourself. Hesselberg has received construction drawings

for small, rowed gunboats. They are inexpensive and fast to build, but a lot smaller than the British frigates. In the narrow and current-ridden straits around Bergen, they may still prove useful. The commandant is old and doesn't know much about warfare at sea, so he leaves organising everything to you. Find the commandant to obtain the drawings, so the construction can begin." Other locations in the game are a rope factory, cooper's shops, mills and an old fortress, now nonexistent. See Figure 4.7 for pictures of five of the locations in the game.

Some locations are intact and appear similar to what they would look like in the early 1800's, such as Bergenhus Fortress, the rope factory and the coopers shop. Others are nonexistent, such as the fortress on Kristiansholm and the mills. One aspect that is brought to the fore in the game is how the locations of the buildings and areas were not a matter of coincidence, but rather chosen because of the favourable characteristics of the physical environment and socio-economic aspects of the city.

The time-spent aspect in the scoring system has been subject to discussion and scrutiny to deevlop other solutions, after contradictions between immersion with the game for the purpose of winning and immersion with the physical environment for the purpose of learning emerged from the data, particularly in Study 1, but also in other studies. In other words, the participants displayed a tendency to want to complete the game as fast as possible in order to win, rather than to spend time observing and making reflections about the locations, which is part of the rationale for this game. The scoring system was inspired by the historical sources — and the sense of urgency in building these boats that can be read there. The building of the boats began in 1807, and their first use took place in 1808. There was also famine in Bergen and Norway in general in this period, which induced a need to alleviate the situation as fast as possible.

5. An Overview of the Empirical Studies

This chapter presents an overview of the empirical studies that have been carried out as part of the research. The research involved taking different yet related approaches to understanding location-based gaming and scenario designs to play the game of PB or to use the SILO system for students to create location-based games. The scenarios have varied in relation to institutional and organisational aspects, scenario design and activity-types as well as regarding the methods and analytical perspectives that were used.

Four empirical studies were carried out and will be presented in chronological order. Emphasis is put on publication outcomes, the contextualisation of the studies and how they relate to the main research question of how mobile, location-based games can be used to facilitate learning. In the first empirical study carried out with PB, Study 1, carried out in a non-educational setting, both the game's usability aspects and educational potential were in focus. Emphasis was put on whether there are any original aspects to locating a game in a physical setting, how the game supports collaboration and to which degree the participants immersed themselves in the game setting. In Study 2 the focus was on how the game could be integrated with other classroom activities as a way of providing a more lasting educational engagement with the historical material on which the game was built. Study 3 addressed the interactional organisation of the game, namely what kind of interactions were necessary to complete it, as a part of the more general question of what the students actually are doing when they are playing PB. In Study 4, a scenario was designed to engage students in using SILO to create games for each other. Each study is presented below.

5.1 Study 1: Usability, Proof of Concept and Educational Potential

Research Paper 1: Wake, J. D. & Baggetun, R. (2009). "Premierløitnant Bielke". A Mobile Game for Teaching and Learning History. *International journal of Mobile and Blended Learning, 1*(4), 12–28.

Also published in: Wake, J. D. & Baggetun, R. (2009). A Mobile Game for Teaching and Learning History. In I. A. Sánchez & P. Isaías (Eds.), *Proceedings of IADIS International Conference on Mobile Learning 2009*, *Barcelona, Spain, February 26 to 28, 2009*, (p. 105–114). IADIS Press.

The first study took place in June 2008, in collaboration with Rune Baggetun, a fellow PhD candidate. It was the first field trial of the PB game and the SILO technology. It was carried out first and foremost to find out whether the game and the technology to support it functioned on a practical level, but it also emphasised usability issues. Thus focus was on the participants' immersion with the game, or the degree to which the gaming was an engaging experience or not, and whether and how the game supports collaboration. Immersion was operationalised in two ways: 1) how the imaginative aspects of the game came into play — and whether playing the game in both a digital and physical setting helped the participants imagine the historical period portrayed through the game; and 2) how the participants experienced the competitive aspects of the game, as the gaming activity was carried out as a competition between teams. The participants' general mobile phone knowledge and habits were also surveyed. Finally, we were interested in the game's educational potential.

A total of nine participants took part in the study, which was set up as a mobile gaming experience. The participants were made aware that the game was designed for learning purposes, although the context for their participation was not. Data were collected through observation of gameplay, a questionnaire and a group interview session.

The results showed that the participants had good general knowledge of mobile phone use and that they used a lot of the functionalities available on the devices, such as opportunities for tailoring the phone and use of Wi-Fi capabilities; the exception was use of media players and instant messaging clients. The participants' responses to the questionnaire indicated that the goal of the game was easy to comprehend and that the interface was easy to use and understand. The game was also reported to be an engaging experience. With respect to which parts of the interface were reported as being used the most, the study revealed that the distance meter and the texts describing the missions were the tools believed to be the most useful, while the map and the hints were used the least. Map features were developed further after this study to make it more useful. Finally, while the participants reported both learning more about Bergen during the Napoleonic wars and seeing the buildings in Sandviken in a new light, the interview session revealed that the participants would have found the experience even more interesting if they had known a little more about the historical context before playing the game. This particular finding, and the study in general, gave useful input to the design of the scenario deployed in Study 2 where PB was integrated with other learning activities and tools in an upper secondary school.

5.2 Study 2: Integration of PB with Classroom Technologies and Activities

Research Paper 2: Wake, J. D., & Baggetun, R. (submitted). Integrating Mobile Location Based Games with Classroom Technologies and Activities: The Memoz Study. Paper submitted to International Journal of Mobile Learning and Organisation.

An account of this learning scenario/field trial is also published in: Krüger, T., Østerud, S., Hoem, J., Schwebs, T., Wake, J., Baggetun, R., Skogseth, E., Bliksrud, M., Heggø, D., & Garfors, Å. (2009). Sluttrapport Memoz. ITU, Fremtidens læringsomgivelser. (Memoz Final Report. ITU, Future Learning Environments.)

Study 2 was carried out within the context of a larger research project, called Memoz (Krüger et al., 2009), lead by the Media Centre at the Bergen District College and including several other participants. The project focused on exploring spatial web publishing in various educational settings, where Memoz was also the name of the tool used for spatial web publishing (Hoem, 2009; Krüger et al., 2009). Capitalising on the spatial orientation of PB and the opportunity to work with maps, we (the authors of Research Paper 2 and the teacher) designed a learning scenario for history that involved the use of both Memoz and PB. Part of the research was to explore how to make the one-time experience of playing PB part of a more sustained effort with learning history. A class of 23 students aged 18–19 and their teacher in an upper secondary school near Bergen took part. The scenario consisted of three 4-hour work sessions. In the first session, Memoz and PB were introduced, a lecture about Bergen during the Napoleonic Wars was given and the students were divided into groups of three or four. Each group was assigned a profession that was important to Bergen during this historical period, and they started preparing a presentation in Memoz about their profession. In session 2 the students played PB. In session 3 the students worked further on their presentations and were encouraged to review and comment on the other groups' presentations in Memoz.

The data collected were observation notes during the classroom and outdoor gaming activities, responses to a questionnaire similar to the one used in Study 1 and the presentations that the students created. The teacher was involved in both the planning and design phase of the scenario, in addition to taking part in an evaluation session afterwards. Regarding the spatial publishing, the analysis revealed that students largely operated in traditional web-publishing modes, or what the teacher labelled "publishing within the (physical) screen". Memoz provides an infinite white space and a large degree of freedom in where to place media elements, but the students operated within the limit of the visible screen. One reason for this was that the tasks that the students were provided with were not explicitly spatial in nature. The Memozes (Memoz products) that the students produced were publicly available on the Internet, and knowledge of this could also have induced the students to cram their material onto a presumed small screen of another reader. The teacher found Memoz

to be a tool that supports creativity in teaching well, as it is rather generic in nature, as in an empty box that can be filled with anything. Two observations that the students were motivated to play PB to win over their fellow classmates were made. One group turned up for the gaming session wearing athletic gear, indicating that these students had understood that it was a competition based on using as little time as possible, and signalling that they intended to run through it. Another group hid a car near to where the game started and used this to complete the game. We had not explicitly stated that this was not allowed.

The possible interactions that the students could involve in as part of the game were studied. Interactions were analytically divided into the following: 1) interactions with the game represented on the mobile phone, 2) interactions with the geographical locations and buildings, and 3) (social) interactions with each other. It was found that the mobile phone seemed to serve as a mediator in tying the group members' individual attention together during discernible phases of gameplay and that the game information became an object for joint thinking. Usually the same person would carry the phone and when they arrived at a location, the group would gather around the phone. Regarding their interactions with the physical environment of the game, the students observed it and brought observations that they thought were significant to the theme in question and completion of the game mission to the attention of the others. This was accomplished with comments such as "Hey, that street is called 'Cooper's Street'" and so on. The game was also found to be played in a highly social way. In the evaluation session, which took place a few weeks after the scenario, the teacher also made the observation that the activities with the Memoz scenario had inspired two separate students' projects, one about Napoleon, as an assignment on a historically significant person, and one project about the influence of European urban architecture on the architecture of Bergen.

5.3 Study 3: The interactional Organisation of Location-based Gaming

Research Paper 3: Wake, J. D., Guribye, F. & Wasson, B. (2011). The Interactional Organisation of Location-based Gaming. In H. Spada, G. Stahl, N. Miyake & N. Law (Eds.), *Proceedings of CSCL 2011*, *Hong Kong, China, June 4 to 8, 2011,* (pp. 136–143). ISLS. (Nominated for Best Design Paper.)

Also published in: Wake, J. D. & Guribye, F. (2010). Using video data to study game players' interaction with a mobile, location-based game for teaching and learning history. Paper presented at: *Interweaving technologies – the aesthetics of digital urban living. University of Copenhagen, Denmark, October 20th – 22nd, 2010*.

Study 3, which took place in the spring of 2010, was a study of the interactional organisation and practical accomplishment of the game play with PB, focusing on how the students used the two main resources available to them in the game space: the game itself on the phone and the physical surroundings. In addition, focus was placed on how the participants made these resources available for each other and how they engaged with the material in the game, including the historical narrative about the surrounding buildings and locations. The participants in the study were students in a master's course on computer-supported cooperative work. Five groups of two to three participants were filmed for the duration of game play, resulting in approximately seven hours of video footage.

Initial analysis of the data revealed that the activities involved with playing the game occurred in four phases, consisting of different activities and choices to be made within them. There was iteration between the last three phases until the game was completed. The first phase, *Briefing*, was the instruction researchers provided to the participants before the gaming activity began, including how the game worked and a short introduction to the historical background. In the second phase, *Search and orientation,* the groups moved towards where they thought the location in question was. In the phase *Arriving at a location*, the participants in the group established

whether they had arrived at the correct location or not. There were basically two alternatives open to them: either to proceed with the game as soon as they arrived within the digital zone around the location or to wait to proceed until they were sure they had found the physical location that the mission described. The actual choice of the group differed between the groups involved, but aspects of the physical location in question and contingency factors such as the direction from where the group arrived at the location, was part of shaping their decisions. In the final phase, *Receiving instructions,* the groups received the next mission.

The detailed interactional analysis revealed, for example, the ways in which the participants made the material and the game space available for each other, how turn taking in a sequentially structured talk within the group mediated game play and how the game also comprised many of the everyday activities of navigation and wayfinding in an urban space. Furthermore, it revealed how different aspects of the game were made explicit as topics for discussion, such as when deciding how to deal with the duality of the location. A final observation was how playing of the game is a collaborative effort dependent on a number of contingent circumstances such as how the groups navigated the streets and how they made use of their knowledge of the physical geography aligned with the navigational aids available in the game.

This study also provided several practical insights into how to conduct video-based studies of location-based gaming, an area not well covered in the literature. These insights were found to be subject to a number of challenges that are distinct from video-based studies of practices taking place indoor in front of a stationary computer.

5.4 Study 4: Students Creating Location-based Games for Each Other

Research Paper 4: Wake, J. D., & Wasson, B. (2011). Supporting creativity in teaching and learning of history through small-group production of mobile, location-based games. In *Proceedings of mLearn 2011. 10th World*

Conference on Mobile and Contextual Learning, Beijing, China, 18–21 October 2011, (pp. 180–188). (Best Paper Award.)

In Study 4, which took place in the spring of 2011, a scenario and a field trial were designed. Here, 27 students in their final year of upper secondary school created location-based games for each other to play. The students were to collect information in various media formats at the different locations they visited when playing the game and transform these recordings into a presentation of their own choice.

The scenario was developed in collaboration with the teacher, who decided to base the scenario thematically within the history curriculum, and more specifically World War 2 (WW2). The reason for choosing this theme is that the school was occupied by Germany during WW2, and there are a plethora of locations relevant to WW2 near the school, which is located in the town centre of Bergen. The scenario spanned 13 hours, was spread over six days over a period of two weeks and contained three basic activities. First the students, divided in eight groups of three to four, would review the wide variety of sources available to them, both digital and printed, and then use the information that they found in these to create a game containing a set of locations. Their teacher prepared a set of 16 relevant locations, which were divided in two sets of eight locations. Four of the groups would then use one set of locations to create a game for one of the other four groups and vice versa. Each group created a game for a corresponding group, who would create a game in return, and each group was aware of which group they were to create a game for/receive a game from throughout the scenario. After playing the game and collecting and creating information at the different locations they visited during gameplay, the groups created a media presentation of their own choice, such as a PowerPoint presentation, a paper-based wallpaper or a movie.

The data collection technique utilised in Study 4 was mainly video, where one group's trajectory through the entire scenario was followed. The teacher and all student groups were interviewed in a semi-structured format after the scenario. The researchers were also present for the duration of the scenario, observing events as

they unfolded. Full analysis of the video material has yet to be completed, but a number of initial observations based on observations of the scenario and the interviews have been made. The creation of the games took place over five 2-hour sessions. All the groups chose to divide the locations between the participants, and write about a couple of locations individually. Then the group would join their locations together when creating the game in SILO. The joint session included the activity of creating a storyline to tie the locations together.

The actual gameplay was carried out successfully for four of the eight groups, but for the other half, the phones failed. Two of these groups chose to print out and play the game using paper; the other two visited different museums carrying exhibitions of the theme in question. An initial review of the footage of the gaming session for the group that was being filmed revealed findings similar to the video data of gaming analysed in Study 3. The students created a wide variety of media presentations. Two groups created annotated picture collections in Microsoft PowerPoint, one group made a paper poster and two groups made videos based on pictures and narratives created at the sites. Two groups made information booklets, and the final group made a presentation containing their experiences with the game and a presentation of their own game.

The students had a large degree of freedom in their choice of a collaboration format, yet most of the groups chose to divide the work as described and come together at the end of the "research" phase to create the game. The students also chose to use a wide variety of digital tools available to them, although this was not part of the scenario design. Examples are MS Word and web-based typewith.me for writing the locations (this could have been done within SILO), Google Street View for matching the map technology used in SILO, facebook.com for creating a password-protected group page for sharing documents and Windows Moviemaker for the groups that chose to create films for their presentation.

There were significant indications of high motivation and immersion with their work when the students worked on their games. For example, they worked during breaks,

were secretive about their games with the other members of the class and refused to share information via informal channels during gameplay. The video footage also reveals a lot of whispering while the students were working. The teacher, in the post-scenario interview, attributed this observation to the competitive aspect of the scenario, as the groups competed against each other in winning the games, which made the failure of the phones rather more unfortunate. One of the students pointed out in the interview that there was also an *economic game-theory-like* aspect to the scenario, as the groups could choose either to create a difficult or easy game for the corresponding group, not knowing what they would receive in return. The same student also pointed out that on one hand they wanted to create a challenging game, while on the other hand they felt responsible for the other group's learning and did not want to create a game that was too difficult to complete.

6. Main Findings, Contributions and Evaluation

In the recent years, developments related to mobile technology have facilitated the emergence of a vast number of games to be played on mobile phones. Several mobile games have also been developed specifically to be used for learning. When the work with the research presented here started, however, studies of the educational practices involving these mobile games were not extensively available. As stated in Chapter 1, the main aim for this research was to explore how mobile, location-based games can be used to facilitate learning, particularly to contribute to filling the research gap on educational practices with mobile, location-based games, with an emphasis on mediated, situated social interaction. For this purpose PB, with a supporting technological framework called SILO, was designed, developed and deployed. Engagement with the game was studied in three different settings. In the first study the usability and educational potential of the game was in focus. In the second study the opportunities for countering the experience of "one-timeness" of game playing and integration with other classroom tools and activities was studied. The third study was an attempt to gain insight into the interactional, organisational and practical accomplishment of gameplay to discover what players were actually doing when playing the game. A fourth study explored the educational potentials of students creating location-based games for each other to play using the SILO framework. The approach to the studies was based on the situated and collaborative nature of learning.

From a methodological perspective, an approach inspired by design-based research was adopted, where data originating from naturally occurring gameplay were used to inform and improve the design, in practical ways, both of the technology itself and also of the activities within the scenarios where the game has been used. Based on a view of learning as a situated, mediated and socially originating phenomenon, an ethnographically inspired approach to data collection and analysis was used, with the view that learning practices should be studied in light of the context in which it takes place. This choice was furthermore supported by the observation that the data material on social learning practices with mobile, location-based games for learning

is still relatively scarce. Therefore, explorative studies that generate knowledge about the social practice of location-based gaming and how to use them in educational institutions are valuable.

6.1 Contributions

The studies carried out for this research contribute to mobile learning research and to researchers interested in the learning practices associated with mobile, location-based games. The main contribution of this research lies in the empirical-based exploration of the educational potential of location-based games through the deployment and study of *in situ* engagement with a location-based game, where the analyses primarily have been based on qualitative data. Furthermore, the contributions arise from the wide perspective taken on the process of development and research, a process that has involved the development of game technology and games, but also the development and studies of contexts for their use. The research conducted has thus been two-sided in nature, in that it incorporates attempts at designing new artefacts for learning and at the same time attempts to understand how the new artefacts affect socially organised processes within established educational practices. Another important aspect is that the research explores both students' engagement with a game made by the researcher and games that students have created for each other.

In the following four sections, each study will be discussed in terms of how it contributes to the research community of mobile learning and learning with mobile, location-based games in particular. The main research focus for each of the studies, and how the main findings relate to them, will be taken as a starting point for each discussion. First, the study of usability issues and issues of the general educational potential of PB will be discussed. Second, the study of how PB could be integrated with existing classroom activities and other digital tools for learning will be discussed. Third, the study of the interactional organisation and practical accomplishment of gameplay to explore what kinds of activities the participants are

involved in when playing PB will be discussed. Fourth, and finally, the study of how students made location-based games for each other to learn history will be discussed.

6.1.1 Usability and educational potential of location-based games

> *Study 1:* This study focused on the use of mobile, location-based technology in a collaborative gaming session and on how it was perceived by the participants.

The starting point for this research was the increased availability of mobile and location-based games and an already established research practice of studying games and how they relate to learning practices. The aim was to use recent technological developments in mobile technology to design and develop a location-based game and study how it might be used for learning history. A game (PB) was designed and developed, and a usability-oriented study of PB was carried out. Three groups of three participants each played the game in competition against each other, and the research focused on identifying issues related to usability and how the game might best be used in an educational context. The main findings in Study 1 can be divided into two main categories: findings related to the gaming experience and organisational, pedagogical and institutional issues.

Main findings related to the gaming experience:

User experience

- Participants found the game easy to understand and play and easily understood the goal of the game.
- Participants experienced a feeling of competition against the other groups. The competitive aspect of the gaming experience was seen as engaging, and the participants displayed indications of lusory attitude.

Interface

- The distance meter in the interface along with the mission descriptions were reported as the most important tools required to complete the game.

- The map and hints were used the least.

Main findings related to the pedagogical/organisational/institutional issues:

- Participants were positive both in terms of relating to the content itself as well as the aspect of mixing the digital with the physical to see buildings in a new light.

- Participants made the point that it would have made the game storyline more interesting to them if they had prior knowledge about the theme in question.

- A contradiction between competing on time in the game in order to win and enjoying the game itself and observing the physical surroundings became apparent.

The general contributions of Study 1 are the empirical findings related to gameplay with mobile, location-based games mentioned above, as the study was carried out at a time when empirically based studies of gameplay were not readily available. The observation that prior knowledge would positively influence engagement with the game informed the design of Study 2, in which the scenario was designed in such a way that the students that participated would work with theme-related content before playing the game. The contradiction between competing in the game and observing the surroundings was amended by re-developing the game in such a way that the game automatically pauses after each new mission is received to allow more time for observation and reflection.

From a methodological perspective, part of the research design for this study was to combine the post-gaming group-interview session with a questionnaire for each participant. The aim was not to be able to generate statistically based generalisable observations, given the small number of participants, but instead to be able to balance voiced opinions during the group interview with the view of each of the participants.

6.1.2 Integrating location-based games with classroom tools and activities

Study 2: The focus of this study was on how the location-based game of PB could be integrated with classroom technologies and activities.

The starting point for Study 2 was an interest in how to integrate PB with classroom tools and activities to facilitate learning, partly informed by the observation that pre-knowledge about aspects of the historical material, such as the Battle of Alvøen, would make the game more interesting to play and perhaps also increase the learning potential related to the singular or once-occurring nature of playing PB. Having completed PB once makes it relatively uninteresting to play again, as much of the gameplay revolves around finding locations that participants have no knowledge of beforehand. Study 2 was a scenario-based intervention study carried out in a third-year class of students in upper secondary school, conducted as a part of Project Memoz (Krüger et al., 2009). The basic structure was to first work with the historical theme of Bergen during the 1800s, organised around professions, by creating digital wallpapers in Memoz and then playing PB, and finally to continue work with the digital wallpapers in Memoz.

Main findings related to the gaming experience:

- Several indications of engagement with the game were observed. One interesting observation was that a group of participants hid a car near the starting point and completed the game by driving.
- The phone mediated the groups' coordination and communication in completing the game. One person would carry the phone, and the group would assemble around that person when they reached a location.
- Participants tried to use cues from the environment to help them in the game, such as bringing relevant street names to the attention of their group.

Main findings related to pedagogical/organisational/institutional aspects:

- The scenario-based approach is vulnerable to unforeseen events that potentially take up a considerable amount of time. There were some problems with installing software in the beginning of the intervention, thus and all planned activities were not carried out (e.g. reviewing/commenting of each other's projects at the end of the scenario).

- The teacher reported that several of the students completed individual projects indirectly related to the gaming experience later in the school year, inspired by the game (e.g. Napoleon, the historical influence of European architecture on the architecture of Bergen).

The main contribution associated with Study 2 lies in the researchers' effort to study how to organise mobile, location-based games to create lasting learning experiences by bridging indoor and outdoor learning activities together. This is identified as a challenge to the field of ML (e.g. Hoppe, 2006). The solution chosen in the design of the scenario was to isolate the gaming experience as much as possible to preserve the motivational aspects of gameplay and to avoid significantly disturbing the experience of observing the physical surroundings of historical Bergen (e.g. by not having students take notes during gameplay). Another contribution lies in the way the design of the scenario was organised. Based on the realisation that for the scenario to be successful the teacher needed to be brought into the planning and design process at an early stage, a pre-scenario workshop included the teacher. This gave us the opportunity to integrate the learning activities with curricular demands. The teacher was also involved with the evaluation of the scenario, which took place in a post-scenario evaluation workshop.

6.1.3 The interactional organisation of location-based gaming

Study 3: This study focused on the practical accomplishment of collaborative gameplay. More specifically, it focused on how participants engaged with the material presented in the game, how they used the resources available to them and how they communicated and coordinated their activity.

Based on the observation of the growth in the availability of location-based games for learning and classroom use, and a lack of studies unravelling the practical details of how these games are actually being played, this study aimed to cast light on what students were actually doing when engaged in location-based gameplay. Based on an interaction analysis of seven hours and 15 minutes of video footage of gameplay, Study 3 addressed how the participants made use of the resources available in the game space — the game itself on the phone, the urban environment and the physical surroundings in general. It also addressed how the participants made these resources available for each other and how they engaged with the narrative presented in the game, in and through their interactions. How they dealt with the narrative in the game is also seen in relation to the historical aspects of actual locations and surroundings. Finally, it examined the interactional organisation and practical accomplishment of the mundane, everyday nature of the orientation and wayfinding associated with playing the game, and how the participants' knowledge of local geography and the resources available in the game featured in the activity. In short, Study 3 focused on the practical detail of how location-based gameplay is carried out, or what students are actually doing when playing PB. As such, its contributions are to the gameplay aspects.

Based on the initial observation that gameplay occurs in four cyclic phases, with internal variance in how participants organised their activities, the main findings of Study 3 are:

- Joint orientation and movement involves making GPS-readings available within the group, by the use of bodily orientation and movement in addition to explicit discussion.

- The sequential structure of conversations and interactions is an important resource in the interactional organisation of gameplay.

- Gameplay is a collaborative effort that relies on a number of contingent circumstances, depending on several factors: 1) how participants practically choose to navigate through the city streets/game route; 2) how they make

use of the resources available to them, such as their knowledge of the city's geography; and 3) how this knowledge is aligned with the navigational resources available on the phone and the hints and textual descriptions in the game.

- Aspects of the game that need to be practically decided are sometimes made explicit and a topic of discussion. For example, the contradiction between finding a physical location that is referred to in the game to observe it for learning purposes and finding the game-accepted location (which is usually much larger) that contributes to winning the game needs to be resolved by the participants and is sometimes made explicit and topic of discussion.

The contribution inherent in Study 3 lies in the focus on aspects of gameplay. Findings related to this can be used to inform the design of location-based games, facilitated by a detailed study of participants' interactions, made possible by making use of video data of the same participants. Study 3 makes explicit some of the ways in which the activities of an educational location-based game player is similar to that of a tourist, with the difference being that the game player is getting to know his or her own city in a new light. In particular, the game player is tying a historical game narrative to buildings and sites by making use of the resources made available in the game. On the other hand, game players rely on their own knowledge of the physical environment (i.e. the city) and of ways of communicating to play the game.

Another contribution of Study 3 is the experience gained from the practical side of gathering video data of participants playing a location-based game (Wake, Guribye & Wasson, 2011). Compared to capturing video data in the classroom, filming participants purposefully, yet arbitrarily, on the move outdoors is associated with a set of challenges. For example, attention must be paid to ensuring sound quality, as the sources of disturbance are far more extensive than indoors. Moreover, it is difficult to choose another camera angle than that of behind the group, as researchers do not know where participants are heading. Capturing facial expressions when

participants are moving, for example, can be difficult under these circumstances, in addition to observing how they are relating to the phone screen. In this light, it may prove interesting to perform a future study using head-mounted cameras on all the participants of a group.

6.1.4 Student-created location-based games

> *Study 4:* The focus of this study as on the educational potential of students making location-based games for each other to learn history.

The main focus of Study 4 was on how students can make location-based games for each other to learn history; both curricular materials and locations around the city were integral parts of the game created. To do this, a scenario was designed where participants reviewed relevant material from a range of sources, used these along with aspects of the city to create location-based games, which they then played. During gameplay, they used the different sites to gather and create material, which was to be used later as a basis for making a digital media product. The work and play was organised in groups — one group made a game for a corresponding group using a pre-defined set of locations, and vice versa. The scenario was tied to and integrated with the history curriculum of a class of third year students in upper secondary school, and the theme of the scenario was World War 2. The analysis of Study 4 presented in this dissertation deals with the general process of the scenario and its deployment, and future analyses will focus on the creative or productive aspects of writing the games collaboratively.

The findings of Study 4 are more closely tied to aspects of pedagogical/organisational/ institutional issues and matters of how the scenario facilitated learning, rather than dealing with aspects of gameplay. The main findings from Study 4 are as follows:

Main findings related to pedagogical/organisational/institutional aspects:

- Students used a wide range of digital tools available online, such as Google Street View, Facebook and typewith.me, for a wide range of purposes and at their own initiative and discretion to support their activities in the scenario.

- Students displayed a high degree of motivation in their work with the scenario. Indications of this were unusual silence during work sessions, noticeable whispering in class while working to avoid revealing information about the game the groups were working on, and working during breaks. In the interviews following the scenario, the teacher attributed this to the fact that they were working with competitive gameplay. Interviews with students also revealed the importance of creating something for "the others" in this respect, meaning that they were responsible for the learning of their fellow students. Additionally, they revealed in the interviews that they thought about the dynamic between creating a game for a group of persons they knew and speculating about what kind of game they would receive in return. For example, one group returned from the gaming session fuming with anger, having confirmed their fear that their corresponding group created a particularly difficult game for them.

- Division of labour: The groups spontaneously divided the work in creating the games by choosing to write two or three locations individually before joining the games together collaboratively.

One of the contributions of Study 4 is the originality of students collaboratively creating location-based games for each other to play. The scenario mixed aspects of using the curriculum and curriculum-near sources, but also the physical locations around the town centre of Bergen to create these games. Furthermore, the interaction to be performed on the site of each location in the game was designed to be interacted with more extensively than what has been the case in earlier implementations and studies of scenarios with PB. Here, we decided that to record pictures and video in

the form the participants chose themselves represented the correct balance between meaningful interactions with the location and experiences of flow related to the gameplay. Study 4 also cemented the previously described importance of working with teachers when planning scenarios where the introduction of new classroom technologies is involved, both for understanding the practical limitations of time and other institutional aspects and how to integrate the pedagogical aspects of the scenario with demands from the curriculum plans and learning goals.

6.2 Comparison of Results

In this section, a discussion of how the results presented in this thesis compare to outcomes of similar research is provided. Three recent doctoral dissertations within the area of mobile, location-based games and learning constitute the main point of comparison, specifically the dissertations of Ejsing-Duun (2011), Lonsdale (2011) and Spikol (2010). The discussion is organised around three themes — 1) what kinds of tools are needed to explore how mobile, location-based games can be used for learning; 2) the focus on practice; and 3) the integration of the said technology with existing classroom practices — and it concludes with a discussion of the general potential of mobile, location-based games for learning.

What kinds of tools are needed to explore location-based games for learning?

The starting point for this research was to explore how mobile, location-based games can be used to facilitate learning. To be able to do this, it was necessary to develop tools so this question could be explored in practice, with actual game technology. It was necessary to have a game for students to try out and play. It also became necessary to create a tool for creating games — a technology for tying information to locations. Hence a web-based tool for authoring location-based games was designed and developed, which in turn was used to create a game.

Most existing research exploring mobile technologies for learning purposes has been carried out using the same kind of development of technology, that is a two-component system consisting of an authoring and administration tool, in addition to an application to be used on a mobile device, where the authoring tool is intended to be used on a stationary computer. One example is EagleEye (Jong, Luk & Le, 2012), which consists of a tool for authoring location-based content for school trips (LERAT) and a tool for displaying the content on mobile devices (GEP), in addition to storing the content (RS) and viewing student response (TC). Another example is PaSAT, developed as a part of Londsdale's (2011) PhD work on location-based games, which is structured as a toolkit for creating location-based games, a game server and a client for a mobile device. PaSAT was used to create the mobile game of BuildIT, as mentioned in Chapter 4.

At the time of design and development of SILO and PB, tools for creating location-based content and applications were not widely available. In recent years, however, several systems have become publicly available, both as open source projects and commercial products. For examples of these systems, see the list on pages 66 and 67. These systems make it possible to develop location-based content, also in the form of games, without creating a separate authoring and administration tool. As an example, Ejsing-Duun's (2011) PhD work on location-based games included developing a game on the commercial DJEEO platform.

Focus on practice

The approach to establishing mobile, location-based games' learning potential is based on the assumption that the potential is closely linked to what kind of practices such games entail for students. In other words, to understand how mobile, location-based games can be used to facilitate learning it is necessary to understand the activities involved in playing the games, or what students are actually doing when playing them. This merits a scientific focus that brings researchers close to game

players' observable actions and speech. The rationale of this approach is explained in further detail in Section 3.4.

Ejsing-Duun (2011) has studied players' practices with location-based games and how they create meaning from them, or more specifically, how players create an experience with location-based games relative to their context. Related to players' practices Ejsing-Duun (2011) focused on how game rules are used to hinder effective solutions to the goal of a game to make it challenging for participants (for example, it is not permitted to use your hands to score a goal in football). Yet, these rules are subject to interpretation and negotiation by participants and can be seen in their actions and responses to the game elements as they play. The latter observation is part of the rationale for taking an empirical approach to the in-situ study of game play, as has been done in this thesis.

Ejsing-Duun (2011) also made the point that in location-based games, rules can be unclear and should hence be carefully designed to avoid confusion on behalf of the players, and to avoid giving the players the feeling they are cheating. In the data material for Study 2, for example, one group of participants hid a car near the starting point of the game and used it in an attempt to complete the game faster than their classmates. The rules in PB do not explicitly exclude the use of a car, although there is a more general assumption that competitive games should be conducted under equal conditions for all participants. With respect to the discussion of rules, this can serve as an example that the design of location-based games comes with additional challenges regarding game design.

Ejsing-Duun (2011) also found that different game dynamics can support different approaches to gameplay and distinguished between the approach of exploring the surroundings and narrative and the approach of competing. Players' approaches arise from what they find enjoyable and motivating in games. Ejsing-Duun found the two approaches contradictory and stated that a game design should support a balance between the two. Supporting the approach of competition could, for example, mean using game mechanisms that makes it easy to compare progress, such as points. The

balance between these two approaches was a central focus in the design process of PB and the scenarios in which it was used, as it was a goal for the participants to explore their surroundings, but within the context of the game. The studies of gameplay with PB made it evident that the competitive elements of the game, whilst motivating, came at the cost of exploration of the surroundings. In Study 4, the gaming scenario was designed to enhance interaction at each location, so that participants were required to capture media at each location and use them in a later presentation.

Integration with the classroom

As educational use of mobile, location-based games was one of the goals of this research, it became desirable to try out the technology in actual school settings. Hoppe (2006) pointed out that this is a critical step towards sustainable mobile learning. This required integration of SILO and PB with classrooms' technology and activities. Including the technology in an actual school setting made it apparent that careful attention needs to be paid to organisational and cultural constraints of an institution such as school. For this research, that has for example involved relating to constraints on time particular to school and on how teachers organise their teaching, either in terms of curricular demands or in terms of their ideas about learning.

For Spikol (2010), the approach to support educational adoption of learning with for example mobile and ubiquitous technologies and location-based games, or "bridge the gaps across learning and technology" (p. 22,) is the approach of design. His notion of design is inspired by design based research, and design science (Simon, 1996). Based on an observation of the rapid development and adoption of technologies outside formal learning environments, Spikol identifies the research need to use a design perspective in the development of new technologies and activities for learning. The challenge, according to Spikol (2010), is not necessarily to "engineer solutions" (p. 26), but rather to address social challenges. Design should support the creation of materials and artefacts that make sense to the learners,

specifically to "allow them to be active participants in creating and owning artefacts for learning, rather than being restricted to instruction and consumption of existing knowledge" (p. 26).

The design of the learning scenario for Study 4 in this thesis could represent an exemplification of such an effort, as students were put to work as creators of learning materials for each other, using SILO. In study 4 it was found that working with SILO in this scenario was very motivating for the students, and it was also found that the students scaffolded themselves with digital tools available online, when the need arose. Spikol (2010) offers an additional layer to the design process in the form of a design toolkit: D*TELL (Design Toolkit for Emerging Learning Landscapes) that integrates design requirements for learning with mobile and ubiquitous technology with a model of the different participants, phases and outcomes of a design process. Through the development of D*TELL, Spikol (2010) further supports designers, researchers and teachers in overcoming the challenges inherent in creating learning environments that build on mobile and ubiquitous technology.

The educational potential of mobile, location-based games

What are the opportunities for education with mobile, location-based games? For economic and practical reasons, mobile computing devices are believed to have an educational potential distinguishable from PCs or laptops as well as opportunities for creating innovative opportunities for learning when the devices are coupled with ubiquitous technologies such as "sensors, wi-fi and tangibles" (Rogers & Price, 2008, p. 1). Klopfer and Squire (2008) identified five unique features of mobile and handheld computers' properties that are thought to provide "intriguing educational affordances" (p. 204, italics in original):

1) *portability* – can take the computer to different sites and move around within a location

2) *social interactivity* – can exchange data and collaborate with other people face to face

3) *context sensitivity* – can gather data unique to the current location, environment and time, including both real and simulated data

4) *connectivity* – can connect handhelds to data collection devices, other handhelds and to a common network that creates a true shared environment

5) *individuality* – can provide unique scaffolding that is customised to the individual's path of investigation

To exploit these potential applications and uses, situations should be designed to employ unique features such as these. For example, Lonsdale (2011) presented an attempt to create novel and innovative learning scenarios with mobile technology and games, rather than using mobile technology as a medium for the traditional delivery of educational content, or what he labels "anywhere learning" (p. 19) in reference to that students always have access to educational resources as they always carry the device.

The features listed above that have been exploited in the research presented here are *portability, social interactivity* and *context sensitivity.* The *portability* of mobile phones has been utilised to create a *context-sensitive* learning environment where information is provided as part of physical surroundings in the form of a game. Proximity to chosen physical aspects of the surroundings triggers interaction, creating a learning environment substantially different from what is possible within a classroom. Implementations of this learning environment have been designed for *social interaction* between participants, by organising the activities as competitions and collaborations in different forms.

6.3 Evaluation of the Research and Research Approach

Studies 2, 3 and 4 were carried out as interventions in established educational practices of different kinds, inspired by design-based research. A challenge related to carrying out studies in this way, and a challenge that was experienced during this research process, is that there is limited time for interventions and the activities associated with them due to practical issues related to schools. To illustrate this, the duration of Study 2 was about six hours spread out over two weeks. The duration of Study 4 was about 13 hours, also spread out over two weeks. The time constraints were often practical in nature, e.g. the time the teachers were able to dedicate to a theme, but often more institutional in nature, e.g. each school hour is 45 minutes long, and after the classes' one or two history-lessons, another teacher would come to teach them another subject. For research purposes, on one hand, this can be seen as a short time to base conclusions about how students work with the tools and activities that have been designed and tested, and particularly how the tools and activities aligned with emerging learning processes. On the other hand, from the perspective of the everyday workings of the school, to ask a teacher for 10 hours with the students to carry out an intervention, potentially in conflict with the progress of the curriculum within a particular subject, is a very tall order indeed.

For Studies 2 and 4, where teachers were involved in the planning, it became obvious that teachers' and students' time is a precious commodity and a scarce resource. All the teachers involved in the intervention studies dedicated more time than they had available to participate, both in the sense of time available for them as teachers, but also importantly in the sense of time available for the students given the "normal" school curriculum to be covered. Students and teachers are in school for a limited amount of time each day, and they have a lot that they need to carry out in that time.

The limited availability of time can be seen as affecting the studies in two main ways. First, it affected their design, and second it affected the conclusions that can be drawn from them. The studies' design was affected in the sense that the interventions carried out in school settings became tightly scripted activities to ensure that the students

managed to get through all the planned activities. Several of the aspects that might as well have been left for the students to carry out, such as the practical organising of students into groups or practical organising of the activities that were necessary to complete a task, were planned before the intervention took place. In this sense, the interventions take on the character of a sequence of steps to be carried out by the students. In addition, relatively little time was reserved for playful, student-driven exploration with the tools to learn both how to use the tools in terms of functionality and how the tools could be used for learning. In all of the cases, the technology was explained in the nature of a tutorial, and the students went forward with starting to work with them to complete their task, with assistance available, of course.

It seems to be a logical necessity that this way of organising the studies as a whole sets limits on the conclusions that can be drawn. It is tempting to compare the studies with learning tool-related activities that have a more longitudinal character. As an example, the Department of History at the University of Bergen began development of a web-based writing tool called Kark (Oldervoll 1996; Oldervoll, 2003) in 1994 and has fully integrated it with their teaching and learning activities since it was first developed. Wake, Dysthe and Mjelstad (2007) provided an account of how this tool has affected pedagogical, organisational and institutional aspects of the teaching and learning at the Department of History, based on their historical study of more than 10 years of practice with Kark.

On the other hand, short intervention studies of a still under-developed digital tool designed for learning have also invited potential users early in the process of development to give feedback and allowed developers/researchers to observe the tool's use, giving input to further development. This offers several advantages over carrying on with development without users' input in situations of actual use. In particular, the interventions in established educational practices with realistic situations of use have cast light on the organisational and institutional constraints that are likely to affect the future uses of the tool should it become an integrated part of the range of tools permanently available for teachers to work with in school. This would not be possible if the students were brought into a laboratory.

6.4 Remaining Research Challenges

The research and development process reported here has generated interest from the School Board (Hordaland Fylkeskommune) in using location-based games in general and SILO in particular in schools in the area that they govern (upper secondary schools in Hordaland Fylke). SILO is currently being redesigned and redeveloped. One important aspect of this process is that merely making the technology available for download somewhere is not the way forward. On one hand, a "pedagogical package" that comprises both technology and accounts of pedagogical ways of using the tool should be developed in ways that are compatible with organisational constraints on schools. For example, the issue of time constraints should be considered — it should be possible for a teacher to quickly learn how the technology works, in addition to being able to rapidly integrate a use situation with his or her current pedagogical activities. On the other hand, the new version should also support more generic use of the system, e.g. to support the creation of activities other than games, and in contexts other than for learning.

The first version of SILO now resides on a platform that is technologically outdated, since it was originally developed for Symbian. The new version will be developed for on Android and iOS devices. The first version of SILO was not originally designed for classroom use, yet Study 4 revealed that there is a pedagogical potential inherent in students creating mobile games for each other. This should be reflected in the design of the new version, in that user roles are better cared for and that games can be made private, for instance. Finally it is the intention that future versions of SILO should support wider use of the available media formats, such as pictures, sound and video.

6.5 Conclusive Remarks

This research has explored the introduction of mobile, location-based games for learning. A mobile, location-based game called PB with the supporting framework (SILO) for creating mobile, location-based games has been designed, developed,

deployed and studied in four different settings, with differing research angles and foci. Several commonalities of the studies are that they have considered the practice of location-based gaming *in situ* and the analyses have been informed by and built upon qualitative data sources. Inspired by design-based research, the studies have informed improvements of PB, both in terms of the technology and the activities with the game that have been designed. Situated in the field of ML, this research project contributes in several ways to the field, mainly as a perspective on how to introduce new technologies to established educational practices and how this endeavour entails both the development and re-development of the technology, as well as the development and design of activities associated with the technology. The technology to be introduced should align with existing pedagogical practices and institutional constraints to be successful.

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