Mobile Learning Projects--A Critical Analysis of the State of the Art

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Mobile Learning Projects – a Critical Analysis of the State of the Art

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Abstract

This paper provides a critical analysis of Mobile Learning projects published before the end of 2007. The review uses a Mobile Learning framework to evaluate and categorise 102 Mobile Learning projects and to briefly introduce exemplary projects for each category. All projects were analysed with the criteria: context, tools, control, communication, subject and objective. While a significant number of projects have ventured to incorporate the physical context into the learning experience, few projects include a socializing context. Tool support ranges from pure content delivery to content construction by the learners. Although few projects explicitly discuss the Mobile Learning control issues, one can find all approaches from pure teacher control to learner control. Despite the fact that mobile phones initially started as a communication device, communication and collaboration play a surprisingly small role in Mobile Learning projects. Most Mobile Learning projects support novices while one might argue that the largest potential is supporting advanced learners. All results show the design space and reveal gaps in Mobile Learning research.

1 Introduction

Mobile Learning has recently raised a lot of attention. There are a number of explicit Mobile Learning conferences such as WMUTE [W01], IADIS International Conference Mobile Learning [W02], IMCL[W03], MLearn [W04] or Mobile Learning & Edutainment Conference [W05]. Conferences address Mobile Learning as topics or run tracks for it such as ICCGI [W06], ICONS [W07], AICT [W08], ICELW [W09], Microlearning Conference [W10], ICALT [W11], or ICL [W12]. We can certainly expect further publications regarding Mobile Learning from conferences on e-learning and mobile technology, for example, ICWMC [W13], AACE SITE [W14], ICIW [W15], ECIS [W16], IEEE SUTC [W17], ED-Media [W18], EISTA [W19], Mobile HCI [W20], or DeLFI [W21], as well as from a number of scientific workshops. Recently, there have been, or there will also be, special issues in journals such as the Journal of Computer Assisted Learning [W22], International Journal of Mobile Learning and Organisation [W23], International Journal of Mobile and Blended Learning [W24], Journal on Research and Practice in Technology Enhanced Learning [W25], International Journal of Interactive Mobile Technologies [W26] or the magazine e-learning [W27]. Additionally the International Association for Mobile Learning (IAmLearn) was founded in 2007 [W28]. With mobile learning both growing and maturing as a discipline, there is a need and an opportunity to review progress in the field and offer guidelines for the development of future research projects.

Notwithstanding the increased attention from conferences and publications, there is still no common understanding for Mobile Learning. More precisely, there is not even a consensus about the term itself. There are more or less interchangeable terms such as wireless, ubiquitous, seamless, nomadic or pervasive learning/education, as well as mobile CSCL, and mobile e-Learning. Situations such as the state of creative fuzziness of terms and concepts are typical for an emerging discipline. It is time

now to reflect on the results achieved thus far. We focus on pilot projects, i.e., projects that have developed and tested innovative mobile learning technology in the field. New entrants to this research area can benefit from a systematic analysis of achievements, thus avoiding the repetition of mistakes; consequently, work is done in the most promising areas. This review gives an overview of the design space in mobile learning and allows developers to make better informed design choices. Last but not least, the researchers can more easily identify interesting projects in the structured list (see appendix) and thereby gain better access to the literature.

This paper uses a framework to systematically position and analyze different kinds of Mobile Learning projects found in the most prominent Mobile Learning research literature. We then step forward and critically synthesize central benefits and values for each kind of Mobile Learning, thus going beyond the omnipresent and run-of-the-mill characterization "learning anytime and everywhere." We report the screening of 1469 publications and the analysis of 102 projects from which a number of common hidden pitfalls are revealed and recommendations made on how to avoid or at least relieve them. The discussion is structured according to the Mobile Learning analysis framework, from Sharples and Taylor (Taylor, Sharples et al. 2006; Sharples, Taylor et al. 2007) and analyzes context, tools, control, communication, subjects and objectives of Mobile Learning projects. In the next section we introduce the research methodology and data collection and review prior overviews.

2   Method

2.1   "Review" as a research method

The authors of this article have built up expert knowledge from participating in the project MOBIlearn[1]. Further expertise was gained during five years of field studies with the project mExplorer (Göth, Häss et al. 2004; Schwabe and Göth 2005; Schwabe and Göth 2005; Schwabe, Göth et al. 2005; Göth, Frohberg et al. 2006; Göth, Frohberg et al. 2006; Göth and Lueg 2006; Göth, Frohberg et al. 2007) that was initiated during MOBIlearn and minor field studies when presenting mobile groups with ad-hoc-tasks (Frohberg and Schwabe 2006).

The purpose of this article is to discover common ground and similarities, along with differences, inconsistencies or contradictions within the domain of Mobile Learning. We want to generalize findings from single scientific works and prospect for patterns and gaps in the research field (Fettke 2006) (Mertens and Holzner 1992). The appropriate scientific method to do so is a review (Woodward 1977; Light and Pillemer 1984; Cooper 1988; Cooper and Hedges 1994; Mulrow 1994; Cooper 1998; Fink 1998; Tranfield, Denyer et al. 2003), which is broader than a literature review, but less empirical than a meta-analysis. A literature review is limited to a snap-shot and critical report of the current state-of-the-art, whereas a review is extended by a comparative analysis and an integration of various existing works. A meta-analysis, on the other hand, can only be used to integrate empirical data across different works if all answer one sharply formulated research question (Bortz and Döring 2002). Such a situation does not currently exist in the domain of Mobile Learning.

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[1] EU-IST project, 5th framework. Further information available under http://www.mobilearn.org/ (website checked in January 2008)

The basis of this article is an exhaustive literature review of conference proceedings, state-of-the-art-articles, and journals. The paper offers a survey of mobile learning projects based on a systematic review of publications from: MLearn 2002, 2003, 2004, 2005, 2006, 2007, WM(U)TE (Wireless, Mobile and Ubiquitous Technologies in Education) 2002, 2004, 2005, 2006[2], IADIS (International Association for Development of the Information Society) Mobile Learning 2005, 2006, 2007, and three state-of-the-art-articles by Naismith, Lonsdale et al. (2005), Roschelle (2003), and Trifonova (2003) We also reviewed the papers from the following journals: Journal of Computer Assisted Learning (JCAL), Computers and Education, Journal of the learning science, International Journal of Mobile Learning and Organisation (IJMLO), International Journal of Computer-Supported Collaborative Learning and the International Journal of Learning Technology (IJLT). We started with the review of journal articles in the year 2002 when the first Mobile Learning conference took place. We scanned 570 papers of mobile learning conferences and 887 papers of journals. Additionally, we used the ACM Portal[3] und the IEEE Xplore[4] search engine to find all journal articles that included the key word "mobile learning" in them, and identified 12 further papers in this way. In sum, we scanned 1469 papers.

This set of publications was screened for Mobile Learning projects (the conferences included only Mobile Learning publications; most journals also included other E-learning publications that were not relevant for this review). Any Mobile Learning publication that focussed purely on concepts, frameworks, potential scenarios, technical infrastructure, and technical issues were excluded. Also, projects were not used if they did not include a user test. Further, we expected evidence of technical innovation; accordingly, we selected only projects that met the following criteria:

- Existence of a prototype, i.e., a system that could be given to learners. We expected at least some component that would not be part of a standard configuration of a commercial mobile device.

- Educational oriented user test, i.e., the system was given to authentic users (learners) in an authentic learning context with the goal of learning something. We excluded all projects, where user tests were only done to evaluate adaptivity, performance, technical features, functionality, or usability of a system without clear educational evaluation.

- Availability of robust results, i.e., results needed to be available, scientifically traceable, plausible, relevant and not preliminary only.

Furthermore, we did not consider pure infrastructure projects targeted at providing learners with devices and built up wireless networks. As well, we did not consider learning management systems, technical platforms or unspecific collections of tools without being embedded in a specific learning scenario.

Because of the large number of articles, we could not read them all in detail. Instead, we scanned each article by reading its title, abstract and headings. Papers that did not cover Mobile Learning were dropped. For the remainder we applied our filtering criteria. We expected headings like "prototype," "system," "field test," "user trial," "educational setting," "evaluation," "results" and the

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like. Positive findings were collected and scanned on a deeper level of detail. As soon as it became clear that a project did not meet one of our requirements, we stopped reading. In this manner, we identified 102 Mobile Learning projects. The selected publications were read on a level of detail that allowed us to understand the project in order to rate it according to our analysis framework. The identified projects and their classification are listed in the appendix (Table 8).

We used the task model for mobile learners by Sharples and Taylor (Taylor, Sharples et al. 2006; Sharples, Taylor et al. 2007) as analysis framework. We could have used other frameworks such as Laurillard's Conversational Framework (2002) or TCI – Theme Centered Interaction by Cohn and Matzdorf (1992). We chose Sharples and Taylor's model because it is explicitly targeted at mobile learning. In the next section we introduce the framework and justify its usage. One contribution of this paper is to demonstrate the usefulness of the framework for the purpose of analysis in the domain of Mobile Learning. This has not been done previously to such a large extent.

2.2   The Task Model for Mobile Learners

The task model for mobile learners (Taylor, Sharples et al. 2006; Sharples, Taylor et al. 2007) has its roots in activity theory (Engeström 1987) and was explicitly designed to structure and analyze Mobile Learning, both on a detailed level and meta-level of projects. Sharples and Taylor expand Engeströms model, which fails to resolve the complex interdependencies and dialectic of learning and technology.

The upper part of the triangle of Figure 1 contains the three standard factors: the learner (subject), the learning goal (object(ive)[5]), and the tools that are used to mediate the learning goals to the learner. For instance, tools can be: the teacher, a book, a text, a learning-video, or an e-learning-module. Even an environment and its objects or a certain situation can be used as tools.
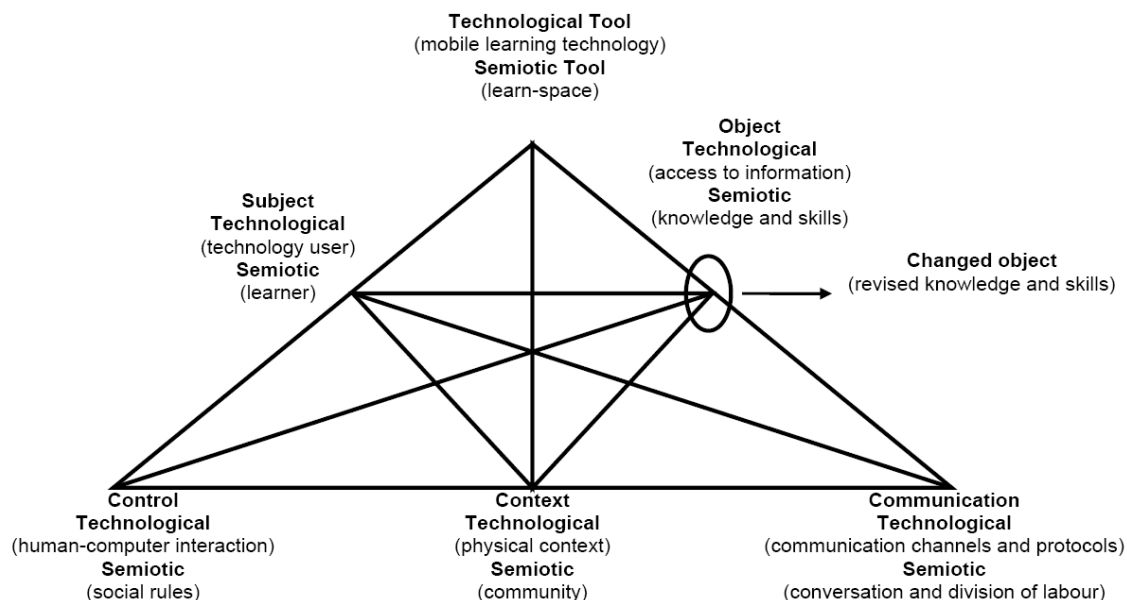

Figure 1: Task model for mobile learning (Taylor, Sharples et al. 2006; Sharples, Taylor et al. 2007)

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[5] Objective would have been a more accurate translation of the Russian [Taylor]

The model extends the standard factors on the baseline of the triangle by three influencing factors (context, control and communication) which are often ignored or handled implicitly in standard learning arrangements, but which turned out to be very relevant for Mobile Learning. One main characteristic for mobile technology is its portability, i.e., devices can be taken into an environment (context) in which it makes most sense to learn. Learning in context raises the challenge to scaffold and moderate the process of learning (control), compared to learning in a classroom. Distance and time must be bridged. Teachers, as well as learners, are in danger of losing track about the ongoing activities. Control is therefore an issue, which has hardly been dealt with in Mobile Learning literature as yet, but which must be planned thoroughly and be handled in a dynamic and flexible way. Mobile technology provides considerable means to support this. And since learning in context is supposed to follow the demands of constructivism, there needs to be communication and cooperation among learners, which improves the reflection on action (Schön 1983). These relevancies will be discussed later in greater detail.

Each factor is connected to all other factors, symbolizing the dynamic and complex interdependencies among them. A variation of one factor always has an impact on other factors. The factors are very useful in reducing the complexity of dynamics when describing a specific instantiation of a learning setting (i.e., a project) in a structured way.

The model addresses another challenge of any computer assisted learning environment (including Mobile Learning). When describing computer assisted learning environments, it is often a source of confusion how to deal with the dialectic of the technological and pedagogical space. Both spaces are linked to each other because technology enables educational processes. However, they must be seen separately because the same technology setting can be used for different educational approaches, and vice versa, the same educational approach can be achieved with different technology settings. The model pays attention to the dialectic as the triangle must be interpreted in at least two layers: the technological and semiotic (Taylor, Sharples et al. 2006; Sharples, Taylor et al. 2007). In this paper we stress the semiotic layer and interpret technology as the enabler.

2.3 Usage of the Task Model for Mobile Learners

The six factors in the framework, namely context, tools, control, communication, subject and object(ive), enable describing any Mobile Learning project in a structured way. In a first step each factor can be portrayed separately and isolated, ignoring the complex interdependencies between factors. Assembling all factors within the triangle produces a complete picture for a specific instantiation of a project. A dynamic view of a project affords building up a new triangle for any instantiation and version. The changes from one instantiation to another can be well documented in this fashion. Unfortunately, there were only very few projects with different well-documented versions. The project mExplorer (the authors' main project) accounts for at least seven versions (Frohberg and Göth 2007).

In the next step, the framework allows for a multi-project-analysis. First of all, projects can be bundled by means of similarity using any of the six factors as dimensions for categories. Section 3 discusses in greater detail why we bundled and categorized projects in contrast to the approach of other researchers.

In a further step of analysis one can compare factors across a high number of projects and find patterns or gaps, and thus draw conclusions for each factor. With an overview it becomes possible to

mark the bandwidth of possible variations and concretize the potential of Mobile Learning. The gap between the current state and the potential helps in identifying the current readiness of Mobile Learning.

In order to reduce complexity, we have defined for each of the six factors one core issue to be presented in detail in the following sections. Each core issue has a scale with two extremes, e.g., very low to very high, on a five-point-scale. This auxiliary construction allowed us to present the analysis down to a single project level by simple figures in Table 8. The figures are based on our evaluation. Furthermore, we added example projects to illustrate the points we wanted to make. If there were several possible examples, we preferred the one being published in a journal or which were known large pathfinder projects.

Table 1 gives an overview of the core factors and will be explained in detail in the following sections. Here it serves mainly as a template for the structure of the rest of this paper.

Section	Issue	Scale				
Factor		**1**	**2**	**3**	**4**	**5**
Section 3: Context (Where and when?)	Relevancy of environment and learning issue	independent context	formalized context	x	physical context	socializing context
Section 4: Tools (Wherewith?)	Pedagogic role of tools	content delivery	interaction for motivation & control	reflective interaction	reflective data collection	content construction
Section 5: Control (How?)	Tightness of control	full teacher control	mainly teacher control	scaffold	mainly learner control	full learner control
Section 6: Communication (With whom?)	Social setting	isolated learners	lose couples	tight couples	communication within group	cooperation
Section 7: Subject (Who?)	Previous knowledge	novice	little previous knowledge	good previous knowledge	much previous knowledge	expert
Section 7: Object(ive) (What?)	Level	know	comprehend	apply	analyze	synthesize and evaluate

Table 1: Overview for scales of issues

3 Prior Overviews and Definitions

The huge variety of Mobile Learning is confusing and challenging to deal with. For instance, it is hard to point out the added value and benefit of Mobile Learning as a whole. Sometimes the added value is convenience, sometimes an increase in motivation, sometimes a higher level of mental or physical activity, and sometimes a provision of better means of controlling learners, or an enrichment of an environment, and so on. At present, we can state specific added values when analyzing specific systems, but not for Mobile Learning in general. There are similar kinds of Mobile Learning projects that can be bundled and treated as a single class of Mobile Learning in order to reduce complexity. But prior overviews have not yet really found an effective means of classifying Mobile Learning. We use a framework with multiple dimensions to analyze the Mobile Learning field in order to capture

the richness of the emerging mobile learning research arena. We believe that only a theoretically grounded framework enables deeper reasoning about the field.

Some prior state-of-the-art articles did not classify Mobile Learning at all, but collected a list of various "typical" projects, e.g., Lehner, Nösekabel et al. (2003) and Trifonova (2003) . Other prior researchers have relied on single factors to structure their overviews of the field. Some used the factors "tools" (Roschelle 2003) because Mobile Learning is simply defined as "e-learning with mobile devices" (Quinn 2000; Kinshuk, Sutinen et al. 2003; Ally 2004; Ally, Lin et al. 2005; Doherty, O'Hare et al. 2006). Roschelle (2003) made a useful distinction of different application types of Mobile Learning: classroom response systems, participatory simulations, and collaborative data gathering. This distinction mirrors the factor "tools" from the user task model.

Naismith, Lonsdale et al. (2005) suggest a classification with the underlying pedagogy of a Mobile Learning setting with six categories: 1) behaviourist, 2) constructivist, 3) situated, 4) collaborative, 5) informal and lifelong learning, and 6) support for learning and teaching. In terms of the user task model, this would mean an "objective" classification of the method and educational paradigm in which the objective is to be reached. Unfortunately, a single setting could be constructivist, situated, informal and collaborative at the same time. A systematic analysis of projects which can be equally positioned in several categories is not possible.
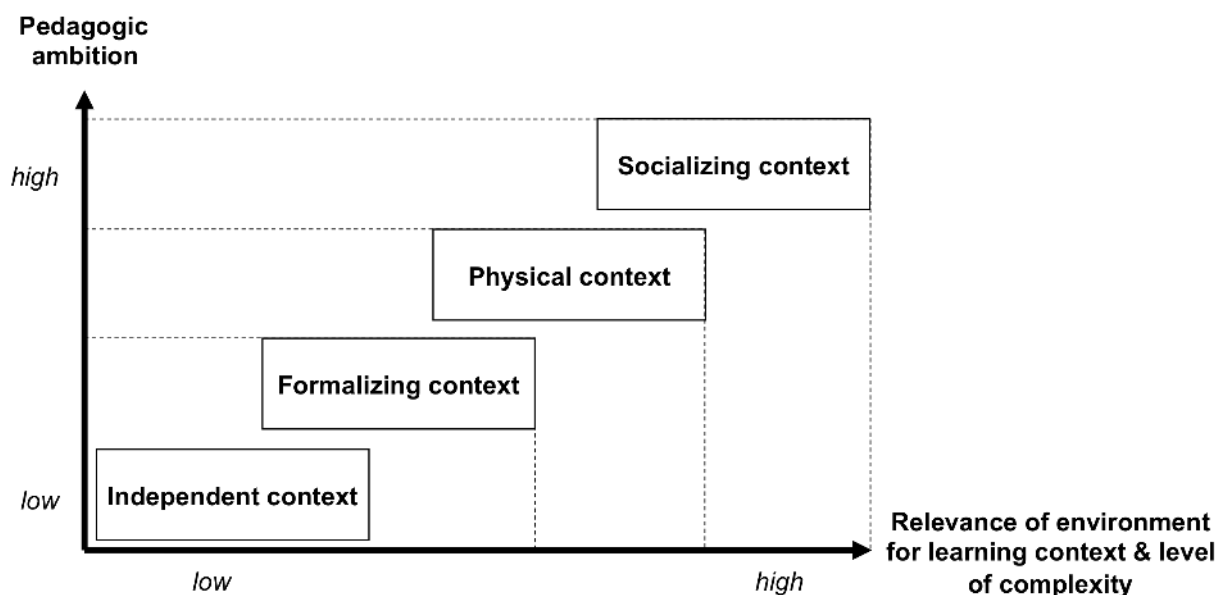
Figure 2: Classification of Mobile Learning by the factor "context"

Frohberg (2008) proposes using context, i.e., where the learning takes place, as a classifying criterion (Figure 2). It has been proven to be robust with disjunctive categories because 118 projects could clearly be positioned inside. Furthermore, the single categories indicate a level of maturity. Providing content to a mobile device (independent context) is, for instance, clearly less advanced and innovative than building a virtual reality for learning (physical context). Context in the understanding of Frohberg (2008) is the first dimension of Sharples et al.'s framework (2007) to be analyzed in the subsequent section.

4 Context

Frohberg's classification consists of four categories: independent, formalized, physical and socializing context. The labelling indicates the relationship between the context of learning with the context of being, i.e., the environment of the learner. The full details of the classification are presented in Frohberg (2008). Below we present a brief overview of the categories and illustrate each with a typical example.

Independent context: Skills Arena and KnowMobile

A project is categorized as "independent" if the current environment of the learner has no relationship to his or her current issue of learning. Skills Arena (Lee, Luchini et al. 2004) is, for instance, a system to drill the basic arithmetic operations anytime and anywhere. There is no specific cognitive advantage for the learner to learn mathematics with Skills Arena in a train. He could as well do it in a bus, at home or at the beach. It does not matter. The context of being is *independent* from the context of learning. It is, of course, not impossible to make use of such a system in a related context as well. The Project Knowmobile (Smørdal and Gregory 2003) provides a mobile access to a medical database anytime and anywhere for medical students. If students make use of it during an internship in a hospital, the transition from independent towards physical context (see below) is smooth.

Formalized context: Classtalk

The context of a learner in a project classified as "formalized" is usually the classroom or a classroom-like setting. Even though the classroom has no cognitive relevancy for the context of learning, it has an organizational function. It synchronizes a number of learners to be within the same context and thus they benefit from each other. The main goal of such projects is the cognitive or corporal activation of learners. Classtalk (Dufresne, Gerace et al. 1996), as prime father and representative for classroom response systems, allows a teacher in a lecture to activate students by, for example, multiple choice questions. The students answer them electronically, and the system converts all answers into a histogram. Thus, a teacher can activate a mass of learners and gain transparency about their knowledge and level of understanding.

Physical context: Museum Projects

If a project is classified as "physical context," the place of being is relevant for the learning issue. Examples here are electronic, mobile museum guides as, for instance, the Tate Modern Multimedia Tour Pilot (Proctor and Burton 2004). Visitors are equipped with a PDA that presents information according to the object in front of which they are standing. The Mobilearn project (Bo 2005) developed a context awareness system that delivered content to museum visitors depending on the museum exhibit they were currently viewing (location) and the time spent in front of the exhibit (thought to reflect personal interest). The location filtered content for relevance to the current situation, while the inferred interest level determined the level of detail of the content. Further contextual information (such as user annotations of content, sharing of content among users, and the user's trajectory within the museum) was used to identify potential areas of interest and provide recommendations for additional exhibits to view. Tests in the Uffizi gallery in Florence confirmed the potential of this approach for utilising context, as well as the challenges involved in capturing context data and providing them to the learner in a useful manner. The Myartspace project (Sharples, Lonsdale et al. 2007) takes a different approach to utilising physical context. The service, run on mobile phones, enables pupils to visit the museum with their schools to capture elements in context in the museum by taking pictures, recording audio clips, writing text notes, and collecting multimedia

content about museum exhibits by typing in a 2-digit exhibit code that is displayed on a label next to the exhibit. Thus, elements of the physical space of the museum are embedded in learners' efforts to represent objects of interest in the personal space on their mobile phones. After the visit, these annotations of the physical space are available to access and share on the virtual space of a visit website.

Socializing context: Loch

Finally, in a "socializing context" learners share sustainable, interpersonal relationships including current or past situations, emotions, friends, learning history, etc. This context covers informal learning (Dohmen 2001), as well as learning in and from everyday situations. There do not yet exist projects which would perfectly fit this category. The five projects listed in Table 2 have only single characteristics or aspects to indicate the principle idea of the category. In the project LOCH (Paredes, Ogata et al. 2005), for instance, users learn a foreign language in everyday situations. The system guides them and a mentor can monitor learners to some extent. Learners can capture certain situations with a camera or by audio recordings.

However, these functionalities are just an entrance into the socializing context. A fully-fledged system would, for example, support an informal community of learners to exchange and reflect everyday situations and act as mutual peer-coaches.

Table 2 is the extraction of the factor context from the overview in Table 1. In our systematic process of selection, we found most projects in physical context, and almost as many in independent and formalized context (see Table 2), but hardly any in socializing context. Note that this distribution of projects over categories has a research bias and may not reflect the real ratio within the practice of Mobile Learning.

Factor	Issue	Scale			
Context (Where and when?)	Relevancy of environment and learning issue	independent context	formalized context	physical context	socializing context
a) No. of projects from Table 8		32	27	38	5
b) Estimation of distribution across the domain of Mobile Learning		hundreds	about 50	dozens	very few

Table 2: Distribution of Mobile Learning projects over categories

Projects in independent contexts are common in mobile learning practice (we estimate hundreds of projects). In order to qualify as a research project, they have to be sufficiently innovative or interesting to be accepted into research outlet. In our research, the contributions had to be beyond pure technology and concepts in order to qualify for further analysis (see section 2.1). We found 32 such projects.

The number of 27 existing projects in formalized context (mainly classroom response systems and participatory simulations) is quite manageable. We know of a number of additional classroom response systems that have been mentioned in other sources. We may have overseen a few more, but there should not be many more than 50 altogether.

The number of 38 projects in physical context is high compared to the diffusion of Mobile Learning to practice because those projects are most innovative and add more knowledge to the nature of Mobile Learning than do those from the lower categories. The majority of projects in physical context passed our process of selection. We know of about double the number of projects from other

sources that were not checked systematically. Many such additional projects are museum guides; others are in mixed environments. There are, as well, more projects supporting expeditions in nature collecting data electronically with sensors. Thus, we estimate the complete number of projects within the field of Mobile Learning to be a few dozen.

There are actually no projects that would completely fit the category socializing context. The five projects[6] contain a number of characteristics that are helpful to indicate the characteristics of this category.

Comparing the numbers in the different contexts in a research context, we conclude that research effort is almost evenly spread across the independent context, formalized context and the physical context. This means that research is evenly spread over different levels of innovation. While about one third of the researchers try to enhance the reach of e-Learning to the mobile arena (= independent context), a little smaller group (formalized context) tries to improve the traditional classroom setting. A third group (one third) strives to move learning to its natural environment. They typically struggle with context awareness as an important enabler of more situated learning. The next frontier (socializing context) is not yet well populated. We see a great potential for researchers to connect mobile learning to social network sites, where learners provide the necessary context information. However, important privacy issues surface here, as well.

In the next sections, we analyse the remaining five factors: tools, control, communication, subject and objective.

5   Tools

"Tools" is the generic term for any material, medium, content, artefact, instrument, device and the like, that is used to mediate a learning process. These can be books, scripts, digital material, maps, manuals, paintings and computer devices. Even language, society or culture could be subsumed under tools (Taylor, Sharples et al. 2006; Sharples, Taylor et al. 2007).

As a core issue for tools, we concentrate on the cognitive method of how tools are used. On the low end of the scale (value 1 - content delivery) there is readily prepared content to be delivered to the learner. This is a one-fits-all-approach maximizing efficiency for the teacher. The learner is only consuming content, being cognitively rather passive, and hopefully gains some factual knowledge with a low level of understanding and a low level of applied knowledge.

On the high end of the scale (value 5 - content construction) the learners are working actively with tools and are producing learning content on their own. This time-consuming approach targets effectiveness for the learners because it leads to a deeper understanding, and knowledge becomes applicable.

Between these two extremes of tool usage we placed three further categories. The value 2 on the scale means 'interaction (with tools) for (the purpose of) motivation and control.' On this level, content is still delivered, but some of it may be consumed more than just passively; for example, there can be a multiple-choice-quiz or content that needs to be searched from somewhere in the environment. This kind of interaction can be an element in a playful approach to learning, and is

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[6] The projects can be identified using Table 8.

supposed to raise motivation. As additional effect, a teacher has the opportunity to gain more control and transparency of what the learner has done when observing the past interactions.

The correspondent to value 3 on the scale is called "guided reflection." Here the tool delivers less content to the user. Instead, it focuses on the given environment, e.g., the surrounding, and gives the learner situated tasks on which to reflect. The learner has to reflect about the environment to precede the tasks.

Value 4 stands for "reflective data collection." Here the learners have to explore an environment on their own. The tool is used as an instrument for measurement and data collection. The purpose is to provide the learner with self-gained and thus meaningful data to reflect and understand the observed phenomena.

Below we describe five projects with different tool support levels.

Content delivery: From e-learning to m-learning

The project "From e-learning to m-learning" (Keegan 2002) was initiated by Sony Ericsson and focused on the technological challenges when delivering prepared course material to a mobile phone. This was one of the first pathfinding m-learning projects. The researchers demonstrated how it is possible to provide access to e-learning content on a mobile phone. Students from several countries used the material and rated it as being "satisfying." m-learning (Traxler 2002) - another early pathfinding project- focused on content delivery and accompanying collaboration support to underpriviledged students on mobile devices. The majority of the participants were unemployed and younger than 19 years. The researchers reported an improvement in students' motivation, independence, literacy and numeracy skills.

Interaction for motivation and control: Musex

In Musex (Yatani, Sugimoto et al. 2004) school children were learning in a museum of emerging science and innovation. The learning was guided by a quiz with 13 questions, running on a PDA. From a pedagogical point of view, a multiple-choice quiz is still a variation of content delivery. Instead of simply listing facts, a closed question is interposed. This intermediate step demands some activity of the learner, i.e., picking the right answer to the question. This activity, the immediate feedback by the system (right/ false answer) plus physical movement in the museum, are supposed to raise motivation. Furthermore, the activity allows the teacher to control whether a learner has successfully dealt with an issue. That would not be the case if a learner read only.

Guided reflection: mExplorer

The mExplorer (Schwabe and Göth 2005) started in 2003 as part of the EU-project MOBIlearn. It is a guided orientation game to a university campus. The tasks in the game were used to engage the learner for further exploration of the environment. A first approach of simple quiz tasks showed that this didn't lead to an active exploration. The next step was the design of interactive tasks with high context integration (Göth and Schwabe 2008). These tasks depended on a specific location in a specific environment. For example, a learner had to find some information in a specific book. To fulfil this task, he had to find the library, learn to handle the library information system to write down the code of the book, understand the library code and the organization of the library, and finally locate the book. So the tool was used to guide the student into a deeper reflection of his surroundings.

Reflective data collection: ImagiProbe

In this project (Vahey and Crawford 2002) a PDA with several sensors was provided, e.g., a sensor for temperature, magnetic fields, light intensity, amperage, etc. The PDA integrated all these sensors and in this way provided the learner with a universal measurement instrument. The idea behind the project is that learners could observe and document natural phenomena in the real world environment, like the water pollution in a river. So students could explore an environment by themselves and use the tool for data collection to reflect on it.

Content construction: Photostudy

This project (Joseph, Binsted et al. 2005) is in the conceptual phase but it shows the idea behind "content construction" very well. Here language learning students created photos or short movies and annotated them with learned vocabulary. This material was transferred to a database where it was rated by experts. This material was also provided to other learners who could discuss the material or undertake tandem learning, which also provided material for mutual exchange and rating. In this way the learners could actively learn languages.

Factor	Issue	Scale				
		1	2	3	4	5
Tools (Wherewith?)	Pedagogic role of tools	content delivery	interaction for motivation & control	guided reflection	reflective data collection	content construction
No. of projects		21	54	11	6	10

Table 3: Overview of the tools usage in the different projects

Pure Content delivery (value 1) is a rather poor way to activate learners or motivate them for deeper reflection. Interactive elements (value 2), such as multiple-choice quizzes, are slightly better, but still allow learners to remain rather passive when just recalling factual knowledge. The large majority of the projects are rated with a value of only 1 or 2. For those 32 projects in the independent context, a value of 1 or 2 is natural and within expectations. But projects from contexts with a higher pedagogic ambition should perform with higher values. Many of them miss to implement elements that support deep reflection, knowledge application and cooperation. However, there are 27 projects with tools supporting reflection, data collection or knowledge construction. Thus, we conclude that the tool support of most projects is not pedagogically ambitious; a strong minority provides tools that aim at realizing higher pedagogical goals.

6   Control

Control reflects on the responsibility of the teacher or the learner for setting the right target and a meaningful process of learning. Control can range from tight teacher control to full learner control (Table 4) Both extremes on the scale, have certain advantages and disadvantages.

Factor	Issue	Scale				
		1	2	3	4	5
Control (How?)	Responsibility for learning process and goal	full teacher control	mainly teacher control	scaffold	mainly learner control	full learner control
No. of projects		53	22	9	11	7

Table 4: Control

Full teacher control is efficient for delivering specific content. Under full teacher control the learners are following the teacher's instructions exactly. Also, all learners do the same thing at the same time, e.g., listen to a talk. The teacher has full transparency about the learning activities as he guides the learners on a direct path to gain knowledge. However, learners have no need to take responsibility, which can have a negative impact on their motivation. They are forced into a role of being mentally passive consumers. Furthermore, learners might perform the right activities but still lack the understanding of what they are actually doing and why they are doing it. They are able to reproduce information, but not necessarily applying it (Ploetzner, Dillenbourg et al. 1999).

Because of these shortcomings there is a high demand for a shift towards greater learner control, i.e., the learners design their learning process on their own and possibly even decide on the learning goal. On this extreme of the scale (full learner control) there is a high danger of overstraining learners. Left alone, they might remain without orientation, fail to perform meaningful activities, develop false conclusions and conceptualizations or stay inactive and frustrated (Dubs 2005). Learners are not synchronized with each other. They do not act within the same mental context and their activities are not coordinated. Thus, the learning becomes inefficient, and synergies among the learners can hardly be realized.

Consequently, the optimal level of control may be in between both extremes; that is, not the value of 5, but the middle value of 3 being most preferable. Learners need sufficient scaffolding to be oriented, but without being dominated. The optimization of the level of control is an important and dynamic challenge for any learning. First, it is dynamic because learners are not homogenous, and each individual may need a different level of scaffolding. Second, the need for scaffolding declines over time. While initially more guidance is needed, ultimately learners can become able to act autonomously. Third, control must be thought through on both an individual level and group level. Fourth, a learning environment may be dynamic and disturb learning or offer unforeseen opportunities (Frohberg and Schenk 2008).

In a mobile setting the additional challenges are to keep transparency and to maintain the capacity to act over distance. With an optimal level of control, each learner individually has enough guidance to be able to act and reflect on his own. On a group level, the learners act in a coordinated way because they understand the interrelation of their activities. They regularly synchronize their mental context and thus benefit from each other with synergistic effects. At the same time, learners have enough elbowroom to apply and construct knowledge actively.

There is very little work which discusses the placement of mobile tools as means of control over time and distance. Classroom response systems and participatory simulations by themselves address certain limited aspects of controlling the learning process. It seems control has not yet been discovered as a critical factor for Mobile Learning in a physical context (Frohberg and Schenk 2008). Consequently, we counted only 9 projects with the preferable value of 3, i.e., best possible scaffolding of learners. In most other projects (53 with full teacher control and 22 with mainly teacher control), we believe that teacher control is rather tight and could be released by making use of mobile means. In a few projects (11 with mainly learner control and 7 with full learner control) we view learners as having less orientation than would be ideal. Very few Mobile Learning projects with physical context explicitly considered, positioned or focused the usage of mobile technology as instruments to gain transparency and steer flexible learning activities there.

This finding sheds light on the evolution of Mobile Learning research because in everyday life, such a function is quite common. Parents give mobile phones to their children so that they can be in touch with them when they are away from home. This finding sheds light on the evolution of Mobile Learning research. Most of the projects reviewed are early attempts at mobile learning, and combining both location-based learning and flexible support for learners is difficult. Some more recent projects (e.g. Environmental Detectives (Squire and Klopfer 2007) or MyArtSpace (Vavoula, Sharples et al. 2007)) are taking a "guided inquiry learning" approach to Mobile Learning.

6.1.1 Projects

It is difficult to rate projects on pure content delivery. One could argue that with control, the learners are fully teacher controlled (value 1) because the learning goal, the content and the didactic method (memorizing) are given and fixed. One could argue equally well that control was fully learner controlled (value 5) since the learners are completely free to determine how much and when they consume the prepared content. A substantial discussion of this conflict of perspectives does not lead anywhere, as both are extremes and do not serve the constructivist idea of scaffolding. Aware of this dilemma, we decided to rate such projects with a value of 1 and not 5.

Mobile technology offers many additional means of managing control more sensitively, dynamically and flexibly; yet few projects make use of this potential. In the following section we present examples for each value.

Full teacher control: Witec

We can learn most about control mechanisms when analyzing classroom response systems (e.g., Witec (Liu, Wang et al. 2003)). Such systems are often designed to moderate the activities of a large group by a central person. The teacher starts and stops sessions such as a quiz, a brainstorming session, or voting, thus activating learners. The input from learners is sent to a central database and cumulated to a histogram. Thus, the teacher gains transparency about the learners' performance. These functionalities for collective reflection are exclusively deployed in classroom response systems within an already very controlled setting. There they are rated with the value 1 in Table 8. Such functionalities would create a huge value if they were used in settings with a lack of control and transparency, e.g., a class of students moving freely in a forest or town.

Mainly teacher control: Bird and Butterfly Watching Learning System

The "Butterfly Watching Learning System (BWL)" (Chen, Kao et al. 2004), which follows the "Bird Watching Learning System" (Chen, Kao et al. 2003), is a very good example of an advanced and otherwise excellent Mobile Learning project. The BWL helps students to identify butterflies and learn about them. In the field test a school-class was transported to a butterfly farm. The teacher made sure that the students would actually find butterflies and observed their activities simply by physical proximity. The students created a picture of a butterfly with a camera attached to their PDA and the system presented a selection of considerable butterflies. A butterfly-database contained typical characteristics of the butterflies, and it was up to the students to finally identify the right one/s. With an integrated quiz tool the learners were forced to repeat their knowledge and thus the teacher had transparency about their knowledge gained.

This butterfly project belongs to the most advanced ones in Mobile Learning. However, even this one does not fully exploit the potential of explorative learning. The setting does not allow the students to explore a natural environment for butterflies freely such as in a meadow. With a lack of tools for mobile moderation, the teacher had good reason to fear a disorientation of his students, e.g., when

not being able to find any butterflies. Furthermore, the students were not supposed to create their own knowledge by observation, but instead consumed factual knowledge from the omniscient database when answering behaviourist multiple-choice tests. Instead, there could have been an empty or fragmentary database with a predetermined structure of what to observe. Conflicting entries by different students could have been a starting point for further observations and discussions. After some initial instruction, the students could have continued to uniformly fill the database as homework.

Scaffold: Virus

Participatory simulations have been rated with the optimum rate of 3. In the exemplary projects Virus (Colella 2000; Klopfer, Yoon et al. 2004) , which where both used in the Palm Education Pioneer Program, learners act as a virtual society with people being healthy, infected or ill. The actual status is shown by a mobile device. The players are physically engaged in social interactions and thus a virtual virus spreads via interfaces of the devices. So the learners are free to interact with whom they want and the system reacts dynamically, giving the interactions a meaning. Actually, control in such participatory simulations is rather tight because learners have to perform their activities according to strict rules. But within the concrete setting, it seems optimal. Less guidance could lead to disorientation about the process and ruin the desired effects. More guidance could ruin the social experience and thus the mental authenticity of the game setting.

Mainly Learner Control: xTasks

xTasks (Ketamo 2003) is a platform for using mobile devices as a multi user text editor. A teacher or tutor gives a task to a group of students and they can use the device for further discussion and the fulfilment of the task. The system supports them with several functions like text sharing, cooperative writing and outline and structure support. However, the learner is guided by instructions being presented on the system, with the capability of a tutor or coach sending instructions in real-time as well. Still, the learner might quickly become overwhelmed if there is no coach online or if a situation demands a quick reaction. Thus, guidance might sometimes be too little.

Full Learner Control: HandLeR

HandLeR (Sharples, Corlett et al. 2002) is a device especially designed for young learners aged 7 - 11. The learner can use it for reading learning material, image annotation, generation of idea maps and communication with other users. The system is explicitly designed for individual learning. The learner can use the device and be more or less left as s/he chooses. There is no guidance being provided by the mobile device on how to use it for learning. HandLeR is a tool, the usage of which is fully learner controlled.

Table 4 shows that most educational settings in Mobile Learning prefer a rather tight guidance by a teacher with little free space for the learners. Often control is realized physically by spatial restrictions and direct interaction or by thorough preparation of an environment with authoritarian instructions. Depending on the learning goal, the target group, their previous knowledge, and their autonomy, a tight control might be acceptable, not to be criticized in principle. However, the real potential of Mobile Learning might be awakened when realizing arrangements with more space and freedom for learners, still giving them guidance by scaffolding their activities.

7   Communication

Learning is not an exclusively individual process; it usually includes social aspects. The learning process is always affected by the interaction and communication with other persons of the learning group, such as the teacher, participants of a course or classmates (Reinmann-Rothmeier and Mandl 2001). If communication and interaction are encouraged by the learning scenario, it leads to deeper knowledge. By discussing, analysing or working together with other learners on a specific learning aspect they start an intensive reflective process. By working together with others learners, they find their own knowledge gaps and deepen the learning (Wild, Hofer et al. 2001). This shows the importance of communication in a learning scenario. Mobile technologies have the potential to improve that communication and interaction in a Mobile Learning scenario by offering different communication channels.

The scale of communication describes the degree of communication and interaction between different learners in a learning scenario. On the one side of the scale there is the isolated learner. She does not interact with anything other than the learning material and the given tools. Additionally, she is responsible for reaching the learning goals on her own. The next level of the continuum is where learners are put together in loosely coupled pairs. They use the same device or consume the same learning material. But the learning scenario forces no additional communication or interaction between the pairs. If the learners are closely paired, the next level of the continuum is reached. They also use the same device or the same learning material, such as the loosely coupled pairs, but the learning scenario gives tasks which are aimed at enhancing the communication or the interaction, for example, solving a specific exercise. They can discuss with each other and help their team mates. This may lead to better reflection, better guidance and faster attainment of the learning goal. Level four of the continuum connects several closely paired teams, and forces the communication or the interaction between them to improve mutual reflection. The last level of the continuum is where the learning scenario forces the collaboration between the teams to fulfil the learning goal. Below, we describe five projects as an example of the five different communication levels.

Isolated: Tate Modern Multimedia Tour Pilots

The Tate Modern Multimedia Tour Pilot (Proctor and Burton 2004) project focuses on a digital multimedia tour guide which directs visitors through the Tate Modern Gallery of London. The visitor of the gallery receives a PDA which delivers context specific information. The information is presented as text, audio, zoomable pictures and videos. There are also interactive elements in the system, such as questions about exhibits. The visitor moves through the gallery and gets the prepared information as he moves to an exhibit. The system is designed only for individual usage, allows no communication and does not provoke further communication. In this way no positive effects of communication are used. Instead, the user merely consumes, rather passively, the information without being forced to reflect.

Loose Pairs: The Lost Worlds of Somers Town

The Lost Worlds of Somers Town (Bradley, Haynes et al. 2005) is quite similar to the Tate Modern project. It comprises a digital tour guide through London, presenting how London looked 200 years earlier. The PDA also delivers location specific multimedia information to the user. The difference is that the system has the opportunity for the usage as pairs. Two PDAs are linked together to present the information simultaneously to two persons. Much of the delivered information is in the form of

audio articles that can be heard by the two persons at the same time. This leads to commentaries and discussions about the information.

Tight Pairs: AmbientWood and mExplorer

Ambient Wood (Randell, Price et al. 2004) is a system to support learners while exploring woods where they are confronted with several ambient devices, like loudspeakers, to play bird sounds or other wood noises, or small displays, to provide videos about the wood. Learners explore the wood in tight pairs. (Cole and Stanton 2003) report on good results of this cooperative exploration like the high advertency.

Also, the mExplorer uses tight pairs. In 2004 we tested the mExplorer with individuals and teams of different group sizes (Schwabe, Göth et al. 2005). The groups played with a single PDA and in this way were forced to interact with their team mates. They had to decide what to do next, how to complete a task or just determine where they were on the campus. The evaluation shows that the team players are much more active and efficient than individuals. The players in teams of two fulfilled 4.41 tasks in contrast to 2.77 fulfilled by individual players. Also, the team building effect and the fun was better. This indicates that tight pairs are a good choice for Mobile Learning systems.

Group communication: Savannah

In contrast to the mExplorer, where interaction happens only between the players in a team, Savannah (Facer, Joiner et al. 2004) focuses on interaction between groups. School children play a simulation in which they are playing lions in the African savannah. They move physically around in virtual savannah areas and survive as a lion. In this way they learn a lot about the balance of predators and prey and the impact of humans on the lions' living space. The evaluation shows that there is a lot of social interaction among the players. The children collaborated in the game but did not collaborate to fulfil the learning goal, e.g., to act as a pride of lions and learn something about that.

Cooperation: MOOP

In the MOOP (Mattila and Fordell 2005) project the system is explicitly designed as a tool to support cooperative learning in school classes. The purpose of the system is to bring different observations from nearby surroundings into the classroom. The learners can make photos, videos and voice annotations with a GPS location tag, exchange them and work with them. Information from the neighbourhood is used in a cooperative learning process. For example, the learners visit a recycling centre and should produce learning materials to answer the questions of why a recycling centre smells and why there are so many birds there. The final discussion takes place right there at the location or later in the classroom. The learner could collaboratively generate his own knowledge.

As described above, communication, interaction and cooperation are important for reflection and, in this way, contribute to learning on the whole and lead to deeper knowledge. The five examples show huge differences between individual learners and learners in loose pairs and groups. individual learners have a lower activity level and lower reflection rate. This observation is supported by data from the mExplorer test (Schwabe, Göth et al. 2005). The literature review shows that most projects focus on learning scenarios with low communication and interaction (see Table 5). From the analysed 102 projects, 49 projects have isolated learners and 29 have learners in loose pairs. Only 24 projects (9 with tight pairs, 7 with group communication and 8 with Cooperation) enhanced the the learning

scenario with advanced communication and interaction. Thus, much potential for deeper reflection and deeper learning is lost.

Factor	Issue	Scale				
		1	2	3	4	5
Communication (With whom?)	Social setting	isolated learners	lose couples	tight couples	communication within group	cooperation
No. of projects		49	29	9	7	8

<div align="center">**Table 5: Communication**</div>

8 Subject and object(ive)

The subjects in a learning process are the learners. Viewing all the projects, we notice one common pattern. The educational settings across all categories are geared to novice learners (89 projects) or learners with very limited previous knowledge (6 projects) such as young pupils, fresh students or first time visitors in museums (see Table 6). Only 7 projects address learners with good previous knowledge. There are no projects with learners that have much previous knowledge or can be called experts.

Factor	Issue	Scale				
		1	2	3	4	5
Subject (Who?)	Previous knowledge	novice	little previous knowledge	good previous knowledge	much previous knowledge	expert
No. of projects		89	6	7	0	0

<div align="center">**Table 6: Subject**</div>

At first glance, the strong focus on novice learners seems natural and does not attract attention. It is simply the easiest to teach something to novice learners on a level of factual knowledge, which can statistically be measured to prove scientifically the effectiveness of the teaching effort. Furthermore, researchers often have easy access to this target group, especially university students. Selecting novice learners is adequate as long as the objective is defined as "transferring factual knowledge." This is usually the case for Mobile Learning in an independent, and very likely, a formalized context. According to Table 6, all projects in both categories address learners with no or little previous knowledge.

But it is not necessarily adequate to select novices in physical or socializing contexts. The fundamental reason to have learners learn in a relevant context is to let them apply and process their knowledge and to acquire new knowledge by themselves, when exploring, cooperating, and thus reflecting on the environment and their activities. Novice learners are usually not expected to be able to perform these higher forms of learning. Rather, they would need to build up a knowledge basis first and perform their activities under tight control.

There is a plethora of well established, conventional ways to lift learners from a novice level up to a trained level, e.g., a guide book, a guided tour, information panels (museum) etc. To position Mobile Learning here, means to extend those ways with a vague value or even to compete with them. By contrast, there is hardly any conventional support for learners that have already reached a trained level and who want to advance. In their continuously evolving context, they have a lack of means and instruments to reflect and process their knowledge, to record and share their insights with others

who are not physically present, and to create material to work with in a self-reflecting or cooperative process.

To position Mobile Learning in this niche would facilitate an innovative learning support that was not possible before and thus establish an immediate value.

Such newly positioned Mobile Learning asks for a different pedagogical paradigm and a reshaping of mobile applications. In accordance with Bloom's well-known taxonomy[7] of educational objectives (Bloom 1953), Mobile Learning should no longer limit itself to create knowledge and comprehension, but rather support learners in applying, analyzing, synthesizing and evaluating their knowledge. Table 7 shows that there are only 18 projects that provide any higher level of learning than factual knowledge or comprehension. And here we were rather generous with our rating.

Factor	Issue	Scale				
		1	2	3	4	5
Object(ive) (What?)	Level	know	comprehend	apply	analyze	synthesize and evaluate
No. of projects		51	33	14	4	0

Table 7: Object(ive)

9   Limitations

Literature reviews are always a selective snapshot in time. We included the most prominent mobile learning conferences and journals, but some prominent mobile learning papers may have been overlooked because they were published in neighbouring disciplines or under a different heading (e.g. Computer Supported Cooperative Learning). As there is no agreed upon definition of Mobile Learning, we had to rely on the community of authors (and reviewers) whether they explicitly or implicitly (by submitting to a Mobile Learning conference or Mobile Learning related Journal) classified papers as contributing to mobile learning. The analysis treats all publications available at the beginning of 2008 the same and thus smoothes out evolutionary or historical insights. Also, classifications are always coarse and have to abstract from nuances in terminology and local context. Further, we may have been mistaken in some classifications. We tried to avoid classification errors by rating papers by two raters and discussing the results, until the ratings converged. Later, all unclear papers were discussed until a consensus was reached. As we took the claims of the research publications at their face value, any errors of their authors also appeared in the survey. Furthermore, promising early research results may not have held the test of time. If the original results were not corrected in subsequent publications, we had no way of correcting them in the survey. As our publication focused on high-level phenomena rather than specific results, such a bias should not have been too problematic.

The choice of Sharples et al's Mobile Learning framework (Taylor, Sharples et al. 2006; Sharples, Taylor et al. 2007) may have led to circularities if a significant number of other Mobile Learning researchers used it to inform their own research. However, this is unlikely as the available publication from 2006 (Taylor, Sharples et al. 2006) has only 11 citations in Google scholar. The newer publication (Sharples, Taylor et al. 2007) was not officially available to authors of the surveyed papers.

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[7] One may use any other taxonomy for learning.

10 Conclusions and summary

In summary, on a meta-level, one can see the way forward to developing Mobile Learning in order to push it towards its greatest potential that is presently hidden. Mobile Learning can best provide support for learning in context. There learners are asked to apply knowledge and not just consume it. Novices are often not ready to do so, thus Mobile Learning should better address more advanced learners first. Content delivery can often be provided by other means; therefore, Mobile Learning should provide instruments to provoke deep reflection, communication and cooperation. With learners participating in pairs or groups, they do not become isolated. Special tools for monitoring and moderation give learners more elbow-room, without losing transparency for the teacher and risking disorientation of learners.

11 Literature

Ally, M. (2004). Using learning theories to design instruction for mobile learning devices. mLearn2004: Mobile learning anytime everywhere, London.

Ally, M., F. Lin, R. McGreal, B. Woo and Q. Li (2005). An intelligent agent for adapting and delivering electronic course materials to mobile learners. mLearn2005: 4th World Conference on mLearning, mLearn 2005.

Arrigo, M., O. D. Giuseppe, G. Fulantelli and M. Gentile (2007). A Collaborative mLearning Environment. Proceedings of the mLearn2007.

Arvanitis, K. (2005). Museums outside walls: Mobile media and the Museum in the Everyday. Proceedings of the IADIS International Conference on Mobile Learning 2005.

Benta, K.-I., M. Cremene and R. Padurean (2004). Multimedia m-learning using mobile phones. Proceedings of the mLearn2004.

Bloom, B. S. (1953). "Thought processes in lectures and discussions." Journal of General Education 7: 160--169.

Bo, G. (2005). Mobilearn - Project Final Report, Mobilearn (IST-2001-37187).

Bollen, L., G. Juarez, M. Westermann and H. U. Hoppe (2006). PDAs as Input Devices in Brainstorming and Creative Discussions. WMUTE 2006: Proceedings of the IEEE 4th International Workshop on Wireless, Mobile and Ubiquitous Technologies in Education, Los Alamitos, CA, USA, IEEE Computer Society.

Bortz, J. and N. Döring (2002). Forschungsmethoden und Evaluation: Für Human-und Sozialwissenschaftler. Heidelberg, Springer.

Bradley, C., R. Haynes and T. Boyle (2005). Adult Multimedia Learning with PDAs - The User Experience. mLearn2005: 4th World Conference on mLearning.

Bradley, C., R. Haynes, T. Boyle, J. Cook and C. Smith (2007). MULTIMEDIA LEARNING OBJECTS FOR MOBILES. IADIS International Conference on Mobile Learning 2007.

Brandt, E. and P.-A. Hillgren (2004). Self-produced video to augment peer-to-peer learning. mLearn2003: Learning with Mobile Devices. Research and Development, London.

Brecht, J., C. DiGiano, C. Patton, D. Tatar, S. Chaudhury, J. Roschelle and K. Davis (2006). Coordinating Networked Learning Activities with a General-Purpose Interface. Proceedings of MLEARN 2006 Conference.

Bull, S. and E. Reid (2003). Individualised revision material for use on a handheld computer. mLearn2003: Learning with Mobile Devices. Research and Development, London.

Burke, M., S. Colter, J. Little and J. Riehl (2005). Utilizing Wireless Pocket-PCs to Promote Collaboration in Field-based. mLearn2005: 4th World Conference on mLearning.

Cacace, F., M. Cinque, M. Crudele, G. Iannello and M. Venditti (2004). The impact of innovation in mediacal and nursing training: a Hospital Information System for Students. Proceedings of the mLearn2004.

Chang, C. Y., J. P. Sheu and T. W. Chan (2003). "Concept and design of Ad Hoc and Mobile classrooms." Journal of Computer Assisted Learning **19**: 336-346.

Chen, C. H. and H.-W. Chou (2007). LOCATION-AWARE TECHNOLOGY IN CHINESELANGUAGE LEARNING IADIS International Conference on Mobile Learning 2007.

Chen, F., B. Myers and D. Yaron (2000). Using Handheld Devices for Tests in Classes, School of Computer Science, Carnegie Mellon University.

Chen, Y.-F., C.-C. Liu, M.-H. Yu, S.-B. Chang, Y.-C. Lu and T.-W. Chan; (2005). Elementary science classroom learning with wireless response devices implementing active and experiential learning. Wireless and Mobile Technologies in Education, 2005. WMTE 2005. IEEE International Workshop on.

Chen, Y.-S., T.-C. Kao and S. Jang-Ping (2003). "A mobile learning system for scaffolding bird watching learning." Journal of Computer Assisted Learning **19**: 347--359.

Chen, Y. S., T. C. Kao, G. J. Yu and J. P. Sheu (2004). A mobile butterfly-watching learning system for supporting independent learning. WMTE 2004: Proceedings 2nd IEEE International Workshop on Wireless and Mobile Technologies in Education.

Clark, S., C. Sutton-Brady, K. M. Scott and L. Taylor (2007). Short Podcasts: The impact on learning and teaching Proceedings of the mLearn 2007, Melbourne.

Cohn, R. C. and P. Matzdorf (1992). Das Konzept der Themenzentrierten Interaktion. TZI Pädagogischtherapeutische Gruppenarbeit nach Ruth C. Cohn. C. Löhmer and R. Standhardt. Stuttgart, Klett-Cotta**: 39--93**.

Cole, H. and D. Stanton (2003). "Designing mobile technologies to support co-present collaboration." Personal Ubiquit Comput **7**: 365-371.

Colella, V. (2000). "Participatory simulations: building collaborative understanding through immersive dynamic modeling." Journal of the Learning Science **9**(4): 471-500.

Cooney, G. and K. A. Keogh (2007). Use of mobile phones for language learning annd assessment for learning, a pilot project Proceedings of the mLearn 2007, Melbourne.

Cooper, H. (1998). Synthesizing Research: a guide for literature reviews. Newbury Park, CA, Sage Publications Inc.

Cooper, H. and L. V. Hedges (1994). Research synthesis as a scientific enterprise. The handbook of research synthesis. H. Cooper and L. V. Hedges. New York, Russell Sage Foundation**: 3--14**.

Cooper, H. M. (1988). "Organizing Knowledge Syntheses: A Taxonomy of Literature Reviews." Knowledge in Society **1**(1): 104--126.

Cortez, C., M. Nussbaum, X. Lopez, P. Rodriguez, R. Santelices, R. Rosasw and V. Marianov (2005). "Teachers' support with ad-hoc collaborative networks." Journal of Computer Assisted Learning **21**: 171-180.

Cortez, C., M. Nussbaum, R. Santelices, P. Rodriguez, G. Zurita, M. Correa and R. Cautivo (2004). Teaching science with mobile computer supported collaborative learning (MCSCL). Wireless and Mobile Technologies in Education, 2004. Proceedings. The 2nd IEEE International Workshop on.

Crom, N. d. and A. d. Jager (2006). M-Eco-Learning: The Evolution from Paper to PDA in Ecotourism Field Work. IADIS International Conference Mobile Learning 2006.

Deng, Y.-C., H.-Z. Chang, B. Chang, H.-C. Liao, M.-C. Chiang and T.-W. Chan; (2005). "Ask the Author": an academic conference supported system using wireless and mobile devices. Wireless and Mobile Technologies in Education, 2005. WMTE 2005. IEEE International Workshop on.

Divitini, M. and E. M. Morken (2005). Blending Mobile and Ambient Technologies to Support Mobility in Practice Based Education: the Case of Teacher Education. Proceedings of the mLearn2005.

Doherty, B. C., P. T. O'Hare, M. J. O'Grady and G. M. P. O'Hare (2006). Entre-pass: Personalising u-learning with Intelligent Agents. WMUTE 2006: Proceedings of the IEEE 4th International Workshop on Wireless, Mobile and Ubiquitous Technologies in Education, Los Alamitos, CA, USA, IEEE Computer Society.

Dohmen, G. (2001). Das informelle Lernen: die internationale Erschliessung einer bisher vernachlassigten Grundform menschlichen Lernens fur das lebenslange Lernen aller, Bundesministerium für Bildung und Forschung (BMBF), Referat Öffentlichkeitsarbeit.

Dubs, R. (2005). Selbstgesteuertes und lebenslanges Lernen: Versuch einer unterrichtspraktischen Begriffsordnung. Aktuelle Aspekte in Schule und wissenschaftlichem Unterricht. Festschrift zum 60. Geburtstag von Christoph Metzger. D. E. H. S. Rolf Dubs, Institut für Wirtschaftspädagogik (St. Gallen): 56--74.

Dufresne, R. J., W. J. Gerace and W. J. Leonard (1996). "Classtalk: A Classroom Communication System for Active Learning." Journal of Computing in Higher Education 7: 3--47.

E. P. de Crom and A. d. Jager (2005). The ME-Learning Experience: PDA Technology and E-Learning in Ecotourism at the Tshwane University of Technology (TUT). mLearn2005: 4th World Conference on mLearning.

El-Bishouty, M. M., H. Ogata and Y. Yano (2006). Learner-Space Knowledge Awareness Map in Computer Supported Ubiquitous Learning. Wireless, Mobile and Ubiquitous Technology in Education, 2006. WMUTE '06. Fourth IEEE International Workshop on: 116 - 120.

Engeström, Y. (1987). Learning by expanding: An activity-theoretical approach to developmental research. Helsinki, Orienta-Konsultit.

Facer, K., R. Joiner, D. Stanton, J. Reid, R. Hull and D. S. Kirk (2004). "Savannah: Mobile Gaming and Learning?" Journal of Computer Assisted Learning 20: 399--409.

Fallahkhair, S., L. Pemberton and R. Griffiths (2005). Dual Device User Interface Design for Ubiquitous Language Learning: Mobile Phone and Interactive Television (iTV). WMTE 2005: IEEE International Workshop on Wireless and Mobile Technologies in Education, Los Alamitos, CA, USA, IEEE Computer Society.

Fettke, P. (2006). "State-of-the-Art des State-of-the-Art." Wirtschafsinformatik 48(4): 257--266.

Fink, A. (1998). Conducting Research Literature Reviews: From Paper to the Internet, Sage Publications.

Frohberg, D. (2008). Mobile Learning. Department of Informatics. Zürich, University of Zurich. **Doctor**.

Frohberg, D. (2008). Mobile Learning. University of Zurich, Department of Informatics. Zürich. **Doctoral**.

Frohberg, D. and C. Göth (2007). mExplorer, Universität Zürich, Institut für Informatik.

Frohberg, D. and B. Schenk (2008). Analyserahmen zur Lernsteuerung bei Mobile Learning. Multikonferenz Wirtschaftsinformatik (MKWI) 2008.

Frohberg, D. and G. Schwabe (2006). Skills and motivation in ad-hoc-collaboration. CollECTeR: Conference Proceedings Collaborative Electronic Commerce Technology and Research.

Goldman, S. V., R. Pea, H. Maldonado, L. Martin, T. White and W. T. the (2004). Functioning in the Wireless Classroom. WMTE 2004: Proceedings 2nd IEEE International Workshop on Wireless and Mobile Technologies in Education, Taoyuan, Taiwan, IEEE Computer Society.

Göth, C., D. Frohberg and G. Schwabe (2006). The Focus Problem in Mobile Learning. Wireless, Mobile and Ubiquitous Technology in Education, 2006. WMUTE '06. Fourth IEEE International Workshop on.

Göth, C., D. Frohberg and G. Schwabe (2006). The Focus Problem in Mobile Learning. WMUTE 2006: Proceedings of the IEEE 4th International Workshop on Wireless, Mobile and Ubiquitous Technologies in Education, Los Alamitos, CA, USA, IEEE Computer Society.

Göth, C., D. Frohberg and G. Schwabe (2007). Von passivem zu aktivem mobilen Lernen. Zeitschrift für E-Learning: Lernkultur und Bildungstechnologie, Back, Andrea; Baumgartner, Peter; Reinmann, Gabi; Schulmeister, Rolf. **Heft 4**.

Göth, C., U.-P. Häss and G. Schwabe (2004). Requirements for mobile learning games shown on a mobile game prototype. Proceedings of the mLearn2004 conference, Rom.

Göth, C. and C. Lueg (2006). First Experiences With a Mobile Information System Supporting Reflective Exploration of Unknown Terrain. 1. Konferenz Mobilität und Mobile Informationssysteme, Multikonferenz Wirtschaftsinformatik (MKWI 2006).

Göth, C. and G. Schwabe (2008). Designing Tasks for Engaging Mobile Learning. Proceedings MLearn2008 conference, Telford, U.K.

Hawkins, G., L. Ball and S. Corey (2007). 21st Century Assessment for 21st Century Learners. Proceedings of the mLearn2007, Melbourne.

Heath, B. P., R. L. Herman, G. G. Lugo, J. H. Reeves, R. J. Vetter and C. R. Ward (2005). "Project Numina: Enhancing Student Learning with Handheld Computers." IEEE Computer 38(6): 46-53.

Hine, N., R. Rentoul and M. Specht (2004). Collaboration and roles in remote field trips. mLearn2003: Learning with Mobile Devices. Research and Development, London.

Hsi, S. (2002). The Electronic Guidebook: A study of user experiences using mobile web content in a museum setting. Wireless and Mobile Technologies in Education, 2002. Proceedings. IEEE International Workshop on.

Hsi, S. (2003). "A study of user experiences mediated by nomadic web content in a museum." Journal of Computer Assisted Learning 19: 308--319.

Hwang, W.-Y., J.-L. Hsu and H.-J. Huang (2007). A Study on Ubiquitous Computer Supported Collaborative Learning with Hybrid Mobile Discussion Forum. Proceedings of the mLearn2007, Melbourn.

Jones, V., J. H. Jo and G. Cranitch (2002). HyWeb: A Holistic Approach to Technology-based Tertiary Education. Proc. of 14th World Conference on Educational Multimedia, Hypermedia and Telecommunications (ED-MEDIA 2002).

Joseph, S., K. Binsted and D. Suthers (2005). PhotoStudy: vocabulary learning and collaboration on fixed & mobile devices. Wireless and Mobile Technologies in Education, 2005. WMTE 2005. IEEE International Workshop on.

Keegan, D. (2002). The future of learning: From eLearning to mLearning, FernUniversität Hagen.

Ketamo, H. (2002). mLearning for kindergarten's mathematics teaching. Wireless and Mobile Technologies in Education, 2002. Proceedings. IEEE International Workshop on.

Ketamo, H. (2003). "xTask – an adaptable learning environment " Journal of Computer Assisted Learning 19: 360-370.

Kinshuk, S. J., E. Sutinen and T. Goh (2003). "Mobile Technologies in Support of Distance Learning." Asian Journal of Distance Education 1(1): 60--68.

Klopfer, E., S. Yoon and L. Rivas (2004). "Comparative Analysis of Palm and Wearable Computers for Participatory Simulations." Journal of Computer Assisted Learning 20: 347-359.

Kusunoki, F., M. Sugimoto and H. Hashizume (2002). Toward an interactive museum guide system with sensing and wireless network technologies. Wireless and Mobile Technologies in Education, 2002. Proceedings. IEEE International Workshop on.

Lai, C. H., J. C. Yang, F. C. Chen, C. W. Ho, J. S. Liang and T. W. Chan; (2005). Improving experiential learning with mobile technologies. Wireless and Mobile Technologies in Education, 2005. WMTE 2005. IEEE International Workshop on.

Laurillard, D. (2002). Rethinking University Teaching. London, Routledge.

Lee, J., K. Luchini, B. Michael, C. Norris and E. Soloway (2004). More than just fun and games: assessing the value of educational video games in the classroom. CHI '04 extended abstracts on Human factors in computing systems, New York, NY, USA, ACM Press.

Lehner, F., H. Nösekabel and G. Bremen (2003). M-Learning und M-Education. Mobile und drahtlose Anwendungen im Unterricht, Universität Regensburg - Lehrstuhl für Wirtschaftsinformatik III.

Light, R. J. and D. B. Pillemer (1984). Summing Up: The Science of Reviewing Research, Harvard University Press Cambridge, MA.

Lin, N. and K. Mase (2006). An Audio-Based Approach to Mobile Learning of Japanese Kanji Characters. Proceedings of MLEARN 2006 Conference.

Liu, T. C., H. Y. Wang, J. K. Liang, T. W. Chan, H. W. Ko and J. C. Yang (2003). "Wireless and mobile technologies to enhance teaching and learning." Journal of Computer Assisted Learning 19: 371--382.

Mattila, P. and T. Fordell (2005). <u>MOOP - Using m-Learning Environment in Primary Schools</u>. mLearn2005: 4th World Conference on mLearning.

McAlister, M. J. and P. H. Xie (2005). <u>Using a PDA for mobile learning</u>. Wireless and Mobile Technologies in Education, 2005. WMTE 2005. IEEE International Workshop on.

Meawad, F. E. and G. Stubbs (2006). <u>A Framework for Interoperability with VLEs for Large Scale Deployment of Mobile Learning</u>. WMUTE 2006: Proceedings of the IEEE 4th International Workshop on Wireless, Mobile and Ubiquitous Technologies in Education, Los Alamitos, CA, USA, IEEE Computer Society.

Melzer, A., L. Hadley, M. Glasemann and M. Herczeg (2006). <u>The Moles and Mini Moles Software System: Bridging the Gap between Indoor and Outdoor Learning</u>. IADIS International Conference on Mobile Learning 2006

Mertens, P. and J. Holzner (1992). "WI - State Of The Art. Eine Gegenüberstellung von Integrationsansätzen der Wirtschaftsinformatik." <u>Wirtschaftsinformatik</u> **34**(1): 5--25.

Milrad, M., M. H. Jackson and D. Bergman (2005). <u>Exploring the potential of mobile services to support learning and communication in university classes</u>. Wireless and Mobile Technologies in Education, 2005. WMTE 2005. IEEE International Workshop on.

Morita, M. (2003). <u>The Mobile-based Learning (MBL) in Japan</u>. C5'03: 1st Conference on Creating, Connecting and Collaborating through Computing, IEEE.

Mulrow, C. D. (1994). "Systematic Reviews: Rationale for systematic reviews." <u>British Medical Journal</u> **309**(6954): 597--599.

Naismith, L., P. Lonsdale, G. Vavoula and M. Sharples (2005). Mobile Technologies and Learning, The University of Birmingham - NESTA Futurelab.

Naismith, L., M. Sharples and J. Ting (2005). <u>Evaluation of CAERUS: a Context Aware Mobile Guide</u>. mLearn2005: 4th World Conference on mLearning.

Naismith, L. and M. P. Smith (2006). <u>Using mobile technologies for multimedia tours in a traditional museum setting</u>. Proceedings of MLEARN 2006 Conference.

Ng'ambi, D. (2005). <u>Mobile Dynamic Frequently Asked Questions (DFAQ) for student and learning support</u>. mLearn2005: 4th World Conference on mLearning.

Noessel, C. (2003). <u>Mobile learning as a service offering with near-term technologies</u>. mLearn2003: Learning with Mobile Devices. Research and Development, London.

Ogata, H. and Y. Yano (2004). <u>Context-aware support for computer-supported ubiquitous learning</u>. Wireless and Mobile Technologies in Education, 2004. Proceedings. The 2nd IEEE International Workshop on.

Ogata, H. and Y. Yano (2004). <u>Knowledge awareness map for computer-supported ubiquitous language-learning</u>. Wireless and Mobile Technologies in Education, 2004. Proceedings. The 2nd IEEE International Workshop on.

Ogata, H., C. Yin, Y. Liu, M. M. El-Bishouty and Y. Yano (2006). <u>Supporting ubiquitous language learning with RFID tags</u>. Proceedings of MLEARN 2006 Conference.

Paredes, R. G. J., H. Ogata, N. A. Saito, C. Yin, Y. Yno, Y. Oishi and T. Ueda (2005). <u>LOCH: supporting informal language learning outside the classroom with handhelds</u>. Wireless and Mobile Technologies in Education, 2005. WMTE 2005. IEEE International Workshop on.

Pintus, A., D. Carboni, G. Paddeu, A. Piras and S. Sanna (2004). <u>Mobile lessons: concept and applications for on-site geo referenced lessons</u>. Proceedings of the mLearn2004.

Ploetzner, R., P. Dillenbourg, M. Preier and D. Traum (1999). Learning by explaining to oneself and to others. <u>Collaborative learning: Cognitive and computational approaches</u>. P. Dillenbourg, Elsevier Science Ltd**:** 103--121.

Polson, D. and C. Morgan (2007). <u>MILK: THE MOBILE INFORMAL LEARNING KIT. COLLABORATING TO DESIGN SUCCESSFUL MOBILE LEARNING APPLICATIONS</u>. IADIS International Conference on Mobile Learning.

Proctor, N. and J. Burton (2004). <u>Tate Modern Multimedia Tour Pilots 2002-2003</u>. mLearn2003: Learning with Mobile Devices. Research and Development, London, Learning and Skills Development Agency.

Proctor, N. and J. Burton (2004). Tate Modern Multimedia Tour pilots 2002–2003. mLearn2003: Learning with Mobile Devices. Research and Development, London.

Quinn, C. (2000). mLearning: mobile, wireless, in-your-pocket learning, LineZine.

Randell, C., S. Price, Y. Rogers, E. Harris and G. Fitzpatrick (2004). "The Ambient Horn: designing a novel audio-based learning experience." Personal and Ubiquitous Computing 8: 177-183.

Reinmann-Rothmeier, G. and H. Mandl (2001). Unterrichten und Lernumgebungen gestalten. Pädagogische Psychologie. A. Krapp and B. Weidenmann, Beltz Psychologie Verlags Union.

Roberts, J., N. Beke, K. Janzen, D. Mercer and E. Soetaert (2003). HARVESTING FRAGMENTS OF TIME, Mobile Learning Pilot Project Consortium.

Roschelle, J. (2003). "Keynote paper: Unlocking the learning value of wireless mobile devices." Journal of Computer Assisted Learning 19: 260--272.

Saito, N. A., H. Ogata, R. G. J. Paredes, Y. Yano and G. A. San Martin (2005). Supporting classroom activities with the BSUL environment. Wireless and Mobile Technologies in Education, 2005. WMTE 2005. IEEE International Workshop on.

Schön, D. A. (1983). The reflective practitioner: How Professionals Think in Action. New York, Basic Book.

Schwabe, G. and C. Göth (2005). "Mobile Learning with a Mobile Game: Design and Motivational Effects." Journal of Computer Assisted Learning 21: 204--216.

Schwabe, G. and C. Göth (2005). Navigating and interacting indoors with a mobile learning game. Wireless and Mobile Technologies in Education, 2005. WMTE 2005. IEEE International Workshop on.

Schwabe, G., C. Göth and D. Frohberg (2005). Does Team Size Matter in Mobile Learning? International Conference on Mobile Business2005, Sydney.

Seppälä, P. and H. Alamäki (2003). "Mobile learning in teacher training." Journal of Computer Assisted Learning 19(3): 330--335.

Sharples, M., D. Corlett and O. Westmancott (2002). "The Design and Implementation of a Mobile Learning Resource." Personal and Ubiquitous Computing 6: 220-234.

Sharples, M., P. Lonsdale, J. Meek, P. D. Rudman and G. N. Vavoula (2007). An Evaluation of MyArtSpace: a Mobile Learning Service for School Museum Trips. Proceedings of 6th Annual Conference on Mobile Learning, mLearn 2007.

Sharples, M., J. Taylor and G. Vavoula (2007). A Theory of Learning for the Mobile Age. The Sage Handbook of Elearning Research. R. Andrews and C. Haythornthwaite. London, Sage: 221-247.

Silander, P., E. Sutinen and J. Tarhio (2004). Mobile collaborative concept mapping - combining classroom activity with simultaneous field exploration. Wireless and Mobile Technologies in Education, 2004. Proceedings. The 2nd IEEE International Workshop on.

Singh, G., L. Denoue and A. Das (2004). Collaborative note taking. Wireless and Mobile Technologies in Education, 2004. Proceedings. The 2nd IEEE International Workshop on.

Smørdal, O. and J. Gregory (2003). "Personal Digital Assistants in medical education and practice." Journal of Computer Assisted Learning 19: 320-329.

So, S. (2007). A Study on the Acceptance of Mobile Phones for Teaching and Learning with Pre Service Teachers. Proceedings of the mLearn2007, Melbourne.

Song, Y. and R. Fox (2005). Integrating M-technology into Web-based ESL Vocabulary Learning for Working Adult Learners. WMTE 2005: IEEE International Workshop on Wireless and Mobile Technologies in Education, Los Alamitos, CA, USA, IEEE Computer Society.

Squire, K. and E. Klopfer (2007). "Augmented Reality Simulations on Handheld Computers." THE JOURNAL OF THE LEARNING SCIENCES 16(3): 371-413.

Takenaka, M., M. Ohkubo, S. Inagaki and H. Kuroda (2006). Development and Pilot Study of a Mobile Phone-aided Mutual Monitoring Support System. WMUTE 2006: Proceedings of the IEEE 4th International Workshop on Wireless, Mobile and Ubiquitous Technologies in Education, Los Alamitos, CA, USA, IEEE Computer Society.

Tan, K. K. and H. L. Goh (2006). "Development of a Mobile Spreadsheet-Based PID Control Simulation System." IEEE TRANSACTIONS ON EDUCATION **49**(2).

Tarumi, H., F. Satake, F. Kusunoki and M. Takahashi (2007). COLLABORATIVE LEARNING WITH FIELDWORK LINKED WITH KNOWLEDGE IN THE CLASSROOM. IADIS International Conference on Mobile Learning 2007.

Taylor, J., M. Sharples, C. O'Malley, G. Vavoula and J. Waycott (2006). "Towards a task model for mobile learning: a dialectical approach." International Journal of Learning Technology **2**(2-3): 138--158.

Thornton, P. and C. Houser (2004). Using Mobile Phones in Education. 2nd IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE 2004), Taoyuan, Taiwan, IEEE Computer Society.

Tranfield, D., D. Denyer and P. Smart (2003). "Towards a Methodology for Developing Evidence-Informed Management Knowledge by Means of Systematic Review." British Journal of Management **14**(3): 207--222.

Traxler, J. (2002). Evaluating m-learning. Proceedings of the European Workshop on Mobile and Contextual Learning.

Traxler, J. and J. Leach (2006). Innovative and Sustainable Mobile Learning in Africa. WMUTE 2006: Proceedings of the IEEE 4th International Workshop on Wireless, Mobile and Ubiquitous Technologies in Education, Los Alamitos, CA, USA, IEEE Computer Society.

Tretiakov, A. and Kinshuk; (2005). Creating a pervasive testing environment by using SMS messaging. Wireless and Mobile Technologies in Education, 2005. WMTE 2005. IEEE International Workshop on.

Trifonova, A. (2003). Mobile Learning - Review of the Literature, University of Trento - Department of Information and Communication Technology.

Vahey, P. and V. Crawford (2002). Palm Education Pioneers Program: Final Evaluation Report, Menlo Park, CA. .

Vavoula, G., M. Sharples, P. Rudman, P. Lonsdale and J. Meek (2007). "Learning Bridges: a role for mobile technologies in education." Educational Technology **XLVII**(3): 33-37.

Virtanen, V., S. John and K. Wright (2002). Nokia and Midwest Wireless Establish Model Wireless Campus at Minnesota State University, Nokia press release. Available online at http://press.nokia.com/PR/200009/790728_5.html.

Virvou, M. and E. Alepis (2005). "Mobile educational features in authoring tools for personalised tutoring." Computer and Education **44**(1): 53-68.

Wentzel, P. (2005). Mobile Learning in the Netherlands: Possibilities of Use of Real-Time Database Access in an Educational Fieldwork Setting. mLearn2005: 4th World Conference on mLearning.

White, T. (2006). "Code talk: Student discourse and participation with networked handhelds." Computer-Supported Collaborative Learning **1**: 359-382.

Wild, E., M. Hofer and R. Pekrun (2001). Psychologie des Lerners. Pädagogische Psychologie. A. Krapp and B. Weidenmann, Beltz Psychologie Verlags Union.

Winters, N. (2007). periLEARN: CONTEXTUALISED MOBILE LEARNING IN THE ERA OF WEB 2.0 IADIS International Conference on Mobile Learning 2007.

Woodward, A. M. (1977). "The roles of reviews in information transfer." Journal of the American Society for Information Science **28**(3): 175--180.

Yang, J. C., C. H. Lai and Y. M. Chu; (2005). Integrating speech technologies into a one-on-one digital English classroom. Wireless and Mobile Technologies in Education, 2005. WMTE 2005. IEEE International Workshop on.

Yatani, K., M. Sugimoto and F. Kusunoki (2004). Musex: a system for supporting children's collaborative learning in a museum with PDAs. WMTE 2004: Proceedings 2nd IEEE International Workshop on Wireless and Mobile Technologies in Education.

Yin, C., H. Ogata and Y. Yano (2006). Using Participatory Simulation Support Learning Algorithms. Proceedings of MLEARN 2006 Conference.

Zancanaro, M., O. Stock and I. Alfaro (2003). Mobile cinematic presentations in a museum guide. mLearn2003: Learning with Mobile Devices. Research and Development, London.

Zurita, G. and M. Nussbaum (2004). "A constructivist mobile learning environment supported by a wireless handheld network." Journal of Computer Assisted Learning **20**: 235-243.

[W01] http://www.wmute2008.org/ March 23-26, 2008
[W02] http://www.mlearning-conf.org/ April 11-13, 2008
[W03] http://www.imcl-conference.org/ April 16-18, 2008
[W04] http://mlearn2008.org/ October 7-10, 2008
[W05] http://www.lttcom.com/mlearning2008/ November 4-6, 2008
[W06] http://www.iaria.org/conferences2008/ICCGI08.html, March 5, 2008
[W07] http://www.iaria.org/conferences2008/ICONS08.html April 13-18, 2008
[W08] http://www.iaria.org/conferences2008/AICT08.html, June 8-13,2008
[W09] http://www.icelw.org, June 12-13, 2008
[W10] http://www.microlearning.org/conferences.html June 25-27, 2008
[W11] http://www.ask4research.info/icalt/2008/ July 1-5, 2008
[W12] http://www.icl -conference.org, September 24-26, 2008
[W13] http://www.iaria.org/conferences2008/ICWMC08.html, March 5, 2008
[W14] http://www.aace.org/conf/site/default.htm March 3-7, 2008
[W15] http://www.iaria.org/conferences2008/ICIW08.html June 8-13, 2008
[W16] http://www.ecis2008.ie/ June 9-11, 2008
[W17] http://sutc2008.csie.ncu.edu.tw/ June 11-13, 2008
[W18] http://www.aace.org/conf/EDMEDIA/ June 30 - July 4, 2008
[W19] http://www.socioinfocyber.org/imsci2008/website/default.asp?vc=5 June 29 - July 2, 2008
[W20] http://mobilehci2008.telin.nl/ September 2-5, 2008
[W21] http://www.gi-ev.de/aktuelles/kalender/detail/eintrag/1046/ September 07-10, 2008
[W22] http://jcal.info/
[W23] http://www.inderscience.com/browse/index.php?journalCODE=ijmlo
[W24] http://www.igi-global.com/ijmbl
[W25] http://www-b4.is.tokushima-u.ac.jp/ogata/MULE-CFP.htm
[W26] http://www.i-jim.org (Vol. 1, No 1, 2007)
[W27] http://www.e-learning-zeitschrift.org/pdf/MobileLearning_Special_Issue_2007.pdf (Vol 4, 2007)
[W28] http://www.iamlearn.caryloliver.com/

Name	Context	Tools	Control	Comm.	Subject	Objective
attaQ (Takenaka, Ohkubo et al. 2006)	independent	2	1	3	1	1
BBC Bytesize (Thornton and Houser 2004)	independent	2	1	1	1	1
Code It (Goldman, Pea et al. 2004)	independent	3	2	3	1	3
DEEP (Traxler and Leach 2006)	independent	1	1	1	1	1
Eijiro (Morita 2003)	independent	2	1	1	1	1
From e-learning to m-learning (Keegan 2002)	independent	1	1	1	1	1
Geometric Game (Ketamo 2002)	independent	1	1	1	1	1
Handler (Sharples, Corlett et al. 2002)	Independent	4	5	1	1	2
HISS - Lernen im Krankenhaus (Cacace, Cinque et al. 2004)	independent	1	1	1	1	1
HyWeb (Jones, Jo et al. 2002)	independent	1	1	1	1	1
IVR (Cooney and Keogh 2007)	independent	2	1	1	1	1
Kanji Learning System (Lin and Mase 2006)	independent	2	1	1	1	1
KnowMobile (Smørdal and Gregory 2003)	independent	1	1	2	2	1
LO (Bradley, Haynes et al. 2007)	independent	2	1	1	1	1
LOTM (Thornton and Houser 2004)	independent	2	1	1	1	1
M-Learning (Fallahkhair, Pemberton et al. 2005)	independent	2	1	1	1	1
M-Quiz (Meawad and Stubbs 2006)	independent	2	1	1	1	1
mid-2000 (Virtanen, John et al. 2002)	independent	1	1	1	1	1
mobileAuthor (Virvou and Alepis 2005)	independent	2	1	1	1	1
MoreMath (Bull and Reid 2003)	independent	2	1	1	1	2
Multimedia m-learning (Benta, Cremene et al. 2004)	independent	1	1	1	1	1
Musis (Milrad, Jackson et al. 2005)	independent	1	1	1	1	1
NAIT (Roberts, Beke et al. 2003)	independent	1	1	1	1	1
PDA Learning Environment (McAlister and Xie 2005)	independent	2	1	1	1	1
Prodcasting (Clark, Sutton-Brady et al. 2007)	independent	1	1	1	1	1
Skills Arena (Lee, Luchini et al. 2004)	independent	2	1	1	1	1
SMS reference and the	independent	1	1	1	1	1

cavalry (Noessel 2003)						
Speech PDA (Yang, Lai et al. 2005)	independent	2	1	1	1	1
Stanford Learning Lab (Trifonova 2003)[8]	independent	2	1	1	1	1
xTask (Ketamo 2003)	independent	5	4	5	1	3
StudentPartner (Hwang, Hsu et al. 2007)	independent	1	1	1	1	1
Xyber-learning (Song and Fox 2005)	independent	2	1	1	1	1
Ask the Author (Deng, Chang et al. 2005)	formal	2	1	2	1	2
BSUL (Saito, Ogata et al. 2005)	formal	2	1	3	1	2
ClassTalk (Dufresne, Gerace et al. 1996)	formal	2	1	2	1	2
Collaborative Note Taking (Singh, Denoue et al. 2004)	formal	2	4	2	2	2
Code Talk (White 2006)	formal	3	2	4	1	3
DFAQ (Ng'ambi 2005)	formal	2	1	2	1	2
Discourse (Naismith, Lonsdale et al. 2005)[9]	formal	2	1	2	1	2
EduClickII (Chen, Liu et al. 2005)	formal	2	1	2	1	2
Educue (Naismith, Lonsdale et al. 2005)[10]	formal	2	1	2	1	2
ftf-CSCL (Cortez, Nussbaum et al. 2005)	formal	3	3	4	1	3
Group Scribbles (Brecht, DiGiano et al. 2006)	formal	2	1	2	1	2
JAPELAS und Tango (Ogata and Yano 2004)	formal	2	1	2	1	3
Learning2go (Hawkins, Ball et al. 2007)	formal	2	2	2	1	2
MCSCL system (Cortez, Nussbaum et al. 2004)	formal	2	1	3	1	2
mLerning Support (So 2007)	formal	2	1	1	1	1
Mobile Notes (Bollen, Juarez et al. 2006)	formal	2	1	2	1	2
Mobile Spreadsheet (Tan and Goh 2006)	Formal	2	2	1	1	1
MoCoCoMa (Silander, Sutinen et al. 2004)	formal	5	4	5	1	2
Numina (Heath, Herman et al. 2005)	Formal	2	2	2	1	1
Pebbles (Chen, Myers et al. 2000)	formal	2	1	2	1	2
PLASPS (Yin, Ogata et al. 2006)	formal	3	2	1	1	3
Qwizdom (Naismith, Lonsdale et al. 2005)[11]	formal	2	1	2	1	2

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[8] The original project website is no longer available. The state of the art article was cited instead.

[9] The original project website is no longer available. The state of the art article was cited instead.

[10] See also the product website: http://www.educue.com

[11] The original report is no longer available. The state of the art article was cited instead.

Savannah (Facer, Joiner et al. 2004)	formal	2	3	4	1	2
SMS Messaging (Tretiakov and Kinshuk; 2005)	formal	2	1	2	1	2
Syllable-MCSCL (Zurita and Nussbaum 2004)	Formal	3	2	5	1	1
Virus (Colella 2000)	formal	2	3	4	1	2
WiTEC (Liu, Wang et al. 2003)	formal	2	1	2	1	2
Ambient Wood (Randell, Price et al. 2004)	physical	3	3	3	1	4
Bird Watching Learning System (Chen, Kao et al. 2003)	physical	3	3	2	1	2
BodyLearning (Noessel 2003)	physical	1	4	2	1	2
Butterfly Watching Learning System (Chen, Kao et al. 2004)	physical	3	2	2	1	2
Caerus (Naismith, Sharples et al. 2005)	physical	1	2	1	1	1
CIls (Chen and Chou 2007)	physical	2	4	1	1	1
CLUE (Ogata and Yano 2004)	physical	1	5	1	1	1
CropViewer (Wentzel 2005)	physical	3	2	2	2	2
Electronic Guidebook (Hsi 2002)	physical	2	2	1	1	3
Environmental Detectives (Squire and Klopfer 2007)	physical	2	2	3	1	3
eSchoolbag (Chang, Sheu et al. 2003)	physical	2	2	4	1	1
Exploratorium (Hsi 2003)	physical	4	2	1	1	3
Garden Explorer (Tarumi, Satake et al. 2007)	physical	2	2	2	1	1
Genius Loci (Noessel 2003)	physical	2	2	1	1	1
Gipsy (Wentzel 2005)	physical	3	2	2	2	2
Hypertag Magus Guide system (Naismith and Smith 2006)	physical	1	2	1	1	1
ImagiProbe (Vahey and Crawford 2002)	Physical	4	1	1	1	1
M-Eco-Learn (Crom and Jager 2006)	physical	2	4	4	3	2
ME-Learning Experience (E. P. de Crom and Jager 2005)	physical	1	5	1	3	4
mExplorer (Göth, Häss et al. 2004)	physical	2	2	3	1	3
Milk (Polson and Morgan 2007)	physical	2	1	1	1	1
Mobile cinematic presentations (Zancanaro, Stock et al. 2003)	physical	2	2	1	2	2

Mobile Learning Passport (Lai, Yang et al. 2005)	physical	3	3	2	1	2
Mobile Lessons (Pintus, Carboni et al. 2004)	physical	2	1	1	1	1
Moles (Melzer, Hadley et al. 2006)	physical	5	4	5	1	3
Moop (Mattila and Fordell 2005)	physical	5	3	5	1	2
Motus2 (Divitini and Morken 2005)	physical	4	4	4	3	3
MoULe (Arrigo, Giuseppe et al. 2007)	physical	5	4	5	1	1
Museum Outside Walls (Arvanitis 2005)	physical	4	5	1	1	2
Musex (Yatani, Sugimoto et al. 2004)	physical	2	1	2	1	1
MyArtSpace (Vavoula, Sharples et al. 2007)	physical	2	2	2	1	2
periLearn (Winters 2007)	physical	5	5	2	1	1
PerkamII (El-Bishouty, Ogata et al. 2006)	physical	2	1	1	1	1
RAFT (Hine, Rentoul et al. 2004)	physical	2	1	3	1	2
TANGO (Ogata, Yin et al. 2006)	physical	2	5	2	1	1
Tate Modern Multimedia Tour Pilots (Proctor and Burton 2004)	physical	1	2	1	1	1
The Lost Worlds of Somers Town (Bradley, Haynes et al. 2005)	physical	1	1	2	1	1
Virtual Exhibitions (Kusunoki, Sugimoto et al. 2002)	physical	1	1	1	1	1
Keyoe (Burke, Colter et al. 2005)	socializing	4	5	1	2	4
KLIV (Brandt and Hillgren 2004)	socializing	5	4	3	3	3
LOCH (Paredes, Ogata et al. 2005)	socializing	5	3	1	3	3
Photostudy (Joseph, Binsted et al. 2005)	socializing	5	4	5	3	1
UniWAP (Seppälä and Alamäki 2003)	socializing	5	3	5	3	4

Table 8: Rated projects