Mobile Learning is Coming of Age
- What we have and what we still miss

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Abstract: Mobile learning has left the status of a new born child. It is time now to implement some structure into the complex and various activities by a framework presented in this paper. The framework classifies mobile learning in the five categories free, formalised, digital, physical, and informal context. Examples for each category are given. Overviewing the existing projects, the framework allows some analysis about missed out potentials of mobile learning. It helps to avoid the repeated reinvention of the wheel.

1 How to Classify Mobile Learning

Mobile learning is a rather new term which received ongoing attention during the new millenium when mobile technology started its strong impact on society. Until now there were only few attempts from literature reviews to give mobile learning some meta-structure which allowed systematic analysis. Some early literature reviews are limited to a collection and description of diverse bundles of activities and projects [Tri03, LNB03], but without an underlying consistent classification. It is not obvious by which criteria a classification of mobile learning could and should be structured in a meaningful way. A classification by deployed technology leads to a dead-end street, because technology is the least stable component in mobile learning. Technology can often be replaced or varied without changing the didactical concept. Roschelle [Ros03, pg.262] tried a useful classification by types of application, i.e. classroom response systems, participatory simulations, and collaborative data gathering. Even this classification was neither generic nor complete, but it covered a good deal of mobile learning activities at that time and still does today. A very promising classification has been suggested by Naismith et al. [NLVS05]. They classified mobile learning projects by "*six broad theory-based categories of activity*"[NLVS05, pg.1], i.e. behaviourist, constructivist, situated, collaborative, informal/lifelong, and support of learning and teaching. Those categories are mainly based on pedagogic paradigms. But there are three weaknesses in this classification.

First, the pedagogy within a mobile learning project is not as stable as one would assume.

Even small changes in the design might shift the project into another category without having changed anything significant. Second, the categories are not sufficiently distinct. A mobile learning project can for example be collaborative, situated, and informal at the same time, which makes it impossible to place a project clearly in one specific category. Without a clear placement, projects can hardly be bundled and compared to analyse common patterns, specific requirements, similar added values, or potentials. It will be hard then to formulate specific guidelines and recommendations. Third, the categories are not explicitly linked with each other. They only allow at best a static placement, but no direction. There is no suggested ripening path for projects to develop by and by from initial phases towards a stage, which exploits the full potential of mobile learning. This paper suggests a persistent, differentiated, but nevertheless intergradient classification, which is supposed to overcome those weaknesses (see chapter 3).

Looking for a sufficient meta criterion, the author suggests *context* to be adequate. Embedding learning in context is the specific value of mobile learning. A classification by context helps to apply technology more tightly focused and to evaluate it. Nyíri reveals succinctly the fundamental role of context in education saying *"Knowledge is information in context"*[Nyí02, pg.4]. Sharples et al. define context in direct relation to mobile learning when they state: "*Context is constructed by learners through interaction: To explore the complexity of mobile learning it is necessary to understand the contexts in which it occurs. Context should be seen not as a shell that surrounds the learner at a given time and location, but as a dynamic entity, constructed by the interactions between learners and their environment. For example, visitors to an art gallery continually create contexts for learning from their paths through the paintings, their goals and interests, and the available resources including curators and other visitors.*"[STV05, pg.5] Naismith et al. hold a more pragmatic view of context, writing: "*Mobile devices give us a unique opportunity to have learners embedded in a realistic context at the same time as having access to supporting tools.*"[NLVS05, pg.15].

On the basis of the most popular conferences (MLearn 2003-2005, WMTE2004-2005), the Journal of Computer Assisted Learning, recent large research projects (mLearning, Mobilearn) and prior literature reviews [Ros03, NLVS05, Tri03, LNB03] the author detected and bundled about 120 projects by five categories. 51 systems have been chosen to be presented in this paper.[1] The five categories are: free, formalised, digital, physical, and social context. An earlier version of the classification has already been used to structure thoughts in a prior publication [SF04]. There it had no value in itself, was not reflected and neither scientifically motivated. It was not introduced as being an instrument for analysis. Chapter 3 catches up with these shortfalls, argues the intergredient nature, and presents a revised version of the classification. But before, in the following chapter each category will be explained in detail and the referring mobile learning projects will be disclosed. Thus it will indicate the persistence and differentiation of each category. In chapter 4 the review from this paper will systematically be used to analyse the vacancies and undiscovered potentials of mobile learning and extrapolate the next steps.

[1] The chosen systems are either unique, well-known, well-described, or specifically adequate to outline the type of category. Less known systems with little innovation or with a lack of sufficient description have been sorted out.

2 Categories of Context in Mobile Learning

2.1 Free Context

Mobile learning activities that are classified as free context activities do explicitely **not** consider the particular context of the learner as relevant for the learning activity. The fact the learner may currently sit in a tour bus, public transportation, plane, in a cafeteria, camping area or on the beach [LNB03, Tri03] is didactically irrelevant for what he is currently learning. He can learn whatever, whenever and wherever he likes - anytime and anywhere. The learner is liberated from restrictions or boundaries of context. The dominant number of free context projects fits the behaviourist learning paradigm as those projects "*adopt a transmission model, where learning takes place through the transmission of information from the tutor (the computer) to the learner*"[NLVS05, pg.13].

Such activities can be seen as first generation of mobile learning projects and are mainly technology driven. The number of known and nameless projects and activities, which fit in the free context category is endless. Some commonly mentioned examples are the widespread platforms of AvantGo[2], Macromedia[3], or e-tutor[4], which facilitate online access to various services and the display of multimedia material on mobile devices. Many more free context projects have been collected by [LNB03].

In contrast to those technology-driven activities there are a number of pedagogy-driven projects, which would fit in the free context classificiation as well. The IST project "m-learning"[Kee05, pg.8] or a project in Africa called DEEP [LPT+05, pg.3] were designed to overcoming social limitations of access to education. They provide access to learning resources by mobile technology to disadvantaged and cut off learners.

Another sub-class of free context projects provide universal mobile applications to learners, such as calendar, learning-games, quizzes, diary, calculator, scheduler etc. Those flexible applications are meant to support learning in general, but do not serve any specific learning goal and thus are not embedded in any specific context. Some are more organisational, administrative, maybe even entertaining applications. Examples are Handler [Tri03, pg.5], the Student Learning Organiser [NLVS05, pg.36], district230 [LNB03, pg.9], or SkillsArena [LLM+04].

2.2 Formalised Context

Mobile learning in a formalised context is learning within a well defined curriculum, being offered by some educational establishment (school, university, conference or private institutions) and led by some central actor, i.e. a teacher, tutor, instructor, moderator, and the like (collective learning). The relevant context is the classroom, lecture hall, auditorium, or seminar room, but could as well be a virtual classroom or several classrooms that are

[2] http://avantgo.com

[3] A number of show cases can be surfed on their webpage http://www.macromedia.com/cfusion/showcase/index.cfm

[4] http://www.e-tutor.ch/site/

connected via video conference. The didactical setting is traditional teaching in a behaviourist one-to-many manner. The larger the number of learners in a class, the less manageable interactivity becomes for the teacher and the worse the efficiency and quality of communication will become [DWN04, pg.55]. Mobile learning promises to overcome some of those challenges with mobile classroom response systems.

"*In its simplest form, a classroom response system allows a teacher to pose a short answer or multiple-choice question. The system instantly collects and aggregates every student's response. Students hold individual handheld response units (which have variously been graphing calculators, WinCE handhelds, or specially purpose infrared beaming units) and send their response anonymously. The teacher's machine aggregates the students' responses and presents them in a coherent form, usually a histogram. From the histogram, the teacher and students can observe patterns in the variation of responses readily and use this shared point of reference to launch into pedagogical conversations*". [Ros03, pg.262]

More advanced classroom response systems support forum- or chat-like discussions, which might be moderated by a teaching assistant [RSTG03, pg.3]. They may also provide feedback functionalities about the teacher's performance (speed, difficulty, break request) [MSG01, pg.2], [LWL$^+$03, pg.374]. The idea of making use of wireless networks and the personal mobile devices, brought along by the learners themselves [BKM05, pg.3], allows a much more flexible employment of those [SNB$^+$01, pg.17]. There are plenty of such mobile classroom response systems being quite redundant. So following there is just a selection of three of the best known and best documented ones: ActiveClass [RSTG03], ConcertStudeo [DDFW03], and WILMA [MSG01]

2.3 Digital Context

Digital context has educational relevance and thus differs from free and formalised context. A digital context is set by computers as playground for the learner and replaces physical context (see chapter 2.4). Advantages of digital context are the full control of the teacher over the learning environment, the independence from physical restrictions, and the reduction and adaptivity of complexity. But there are of course disadvantages like the challenge of authentity. Furthermore digital context until now hardly allowed any physical, social, or emotional activities, because the learner was tied to the screen of the PC and limited to interaction with a machine. One strand of mobile learning is known as *participatory simulations* and supposed to overcome the latter disadvantage [Col98].

"*In participatory simulations, the learners themselves act out key parts in an immersive recreation of a dynamic system. Each learner carries a networked device which allows them to become part of the dynamic system they are learning about. The aim of this approach is to move the simulation away from the computer screen and more into the tangible world that students can interact with. By making them part of the simulation itself, they are engaged in the learning process, and get to immediately see the effect their actions can have on the system as a whole. They do not just watch the simulation, they are the simulation*"[NLVS05, pg.15].

There are a number of such systems from few developers. The archetypal system is Virus[5], in which pupils experience the effect and principles of a spreading virus. Other systems with biological background have been developed like Cooties [ASS04, pg.5], Big Fish - Little Fish, Live long and prosper [6] or Geney [DIL+01]. Further MIT simulations with miscellanous contexts are Tit for Tat, Discussion, Sugar and Spice, Nets Work or Palmagotchi. Savannah allows kids to put themselves in the role of lions and their survival [FJS+04]. The huge number of non-interpersonal simulations and entertainment games on mobile devices, even undoubtely digital context, are not accepted as mobile learning, because there is no obvious benefit of having it mobile at all or they are categorised as free context.

2.4 Physical Context

Physical context is dedicated to situated, cooperative, and explorative learning in a real environment. Projects classified here are likely to contain elements already described in digital context. There is probably potential to upgrade any project from digital context towards physical context. The distinctive, determining, and constitutive attribut is, if a project makes significant educational use of objects, people, places, and physical artifacts from the environment. The role of mobile technology is to enrich the physical environment digitally. Furthermore it allows digital interaction with and manipulation of the physical environment in innovative ways. According to the socio-cognitive paradigm, "*artifacts often play a cognitive role in learning. They are not simply additional elements of the situation. They have an active role and can make significant contributions to understanding*"[TSM+03, pg.10]. Many mobile learning projects provide mobile support to a learner, who explores a prepared and designated learning environment, like a museum (Tate Modern Multimedia Tour Pilots [PB03]), a botanical garden (CAERUS [NST05]), or touristic parts of a city (The Lost Worlds of Somers Town [BHB05], LAND [TPPR02]), a forest (AmbientWood [RPH+02]), or a butterfly farm (Butterfly Watching Learning System [CKJP04]). The mobile learning device usually presents location-sensitive, personalised, and multimedia information about the artifacts and allows the learner interaction like requesting more information, taking notes or photographs etc.

Other mobile learning systems are built for groups of learners on an expedition, e.g. at a river taking experimental probes, collect data, and process it cooperatively (e.g. CCProbeware [Hsi03, pg.311], King Middle School [LNB03]), in a nature reservate endangered by tourist invasion (ME-Learning Experience [dCdJ05]), in a bush-fire burnt forest area (Denali National Park Fire Succession Study[7]), or during a cultural trip of a small team being connected with a large audience, which can live follow up and interact with the team in situ (RAFT [HRS04]).

Moreover there are mobile learning systems, where the real context is enriched and mixed with a digital context. In Environmental Detectives [KSJ02] the learner has to deal with

[5] http://education.mit.edu/pda/

[6] http://education.mit.edu/pda/igenetics.htm)

[7] http://www.concord.org/publications/newsletter/2004-fall/monday.html

a fictive environmental desaster at the site where he currently is. The location-sensitive device allows him to investigate the situation, take virtual soil samples, and interview real people as suspects. Projects at the MIT with a similar concept, but different story are Mystery @ The Museum, Charles River City, and Outbreak @ MIT[8]. The project MGame [GHS04] makes use of a mobile learning setting, which allows fresh students at the university to explore the campus cooperatively in a playful way. They have to solve competitive and cooperative tasks as known from a paper chase, hunt other teams, and can digitally annotate significant places. A variations of mGame is mTourist [GL06], which adresses tourists in a foreign city.

2.5 Informal Context

Here the understanding of context being purely physical is extended by including situations, relations, attitudes, interpretations, emotions, and arbitrary other abstract dimensions. Informal learning is *äny activity involving the pursuit of understanding, knowledge or skill which occurs without the presence of externally imposed curricular criteria"* [Liv00, pg.3]. It happens in context and everyday situations, often spontaneously with low support. There are many opportunities during everyday life, which remain unused for learning, just because no support for learning is given. The learning is not necessarily referring any specific artifacts, is not necessarily based on facts and knowledge. We know from studies of Tough [Vav04, pg.3], Livingstone [Liv00, pg.20], and Vavoula [Vav04, pp.68] that the majoritarian proportion of adult learning happens informal. Despite these facts, there are astonishingly few projects dealing with informal learning. This is striking, because informal learning demands very high grade functionalities, which could excellently be provided by mobile learning.

Projects in an informal context would adress the development of soft factors, social skills, the change of habits (diet), or a general extension of one's repertoire of behaviour or training of one's skills to interact more successfully with other people (leadership training, communication training, sales training etc.). There might be a coach or an interest group (e.g. weight watchers or Alcoholics Anonymous) to support the learning giving advice, motivation, and reflection, but during everyday life, no or little support is available. With mobile learning the isolation felt in everday situations can be reduced and thus create a number of powerful and positive effects.

Mobile support can shift informal learning from an isolated, individual learning towards cooperative learning. However, a few projects contain at least elements to be classified as informal context projects. KLIV [BH04] allows nurse probationers to produce short video clips about what they have learned and share them with others. The project Keyoe [BCLR05, pg.4] supports people to lose weight with diet tracking and nutrition analysis tools. In Moop [MF05] pupils "*bring observations from nearby surroundings to the classrooms and to school teaching situations where they are handled co-operatively*"[MF05, pg.1]. The ActiveCampus Explorer "*supports several location aware applications, inclu-*

[8] http://education.mit.edu/ar/

ding location-aware instant messaging and maps of the user's location annotated with dynamic hyperlinks of nearby buddies, digital graffiti, etc."[GSB+04, pg.1] .

3 Overview Over the Categories

The suggested classification of free, formalised, digital, physical, and informal context was said to be persistent, differentiated, and nevertheless intergradient. Context has been found to be the most persistent structure characteristic in mobile learning, being superior to technology, type of application or pedagogic paradigm (see section 1). The chosen categories seem to be sufficiently differentiated, as all projects could clearly be assigned to one only category each. The next step will be to formulate a certain set of patterns, specific requirements, similar added values, or potentials for each category. But this is not purpose of this paper.

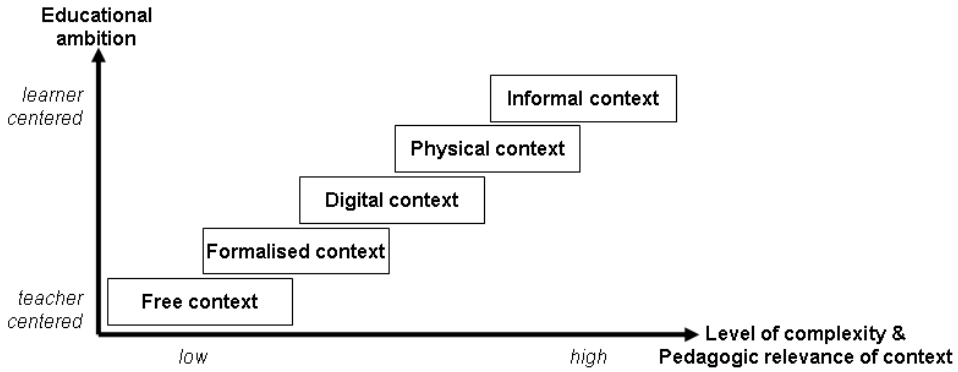

Abbildung 1: Categories for Mobile Learning

Lastly the categories are intergradient allowing mobile learning projects to develop upwards (see figure 1). The chosen order of context categories is therefore not random. A higher category might contain elements from lower ones, but has additionally specific challenges and values. They are put in order following the general dimensions of relevance of context and complexity on the abscissa of figure 1. With a stronger role of context being didactically relevant, there is a higher complexity of the educational setting. Context is didactically irrelevant for learning in free context. In formalised context, it has mainly an organisational function and thus influences the pedagogy only indirectly. In digital context, the pedagogically relevant context is limited to a designed, virtual learning environment. Physical context might build on and extend digital context. In physical context, reality with all its artifacts is highly and explicitely relevant. In informal context the borders of context are extended from tangible artifacts by emotions, relationships, attitudes, and more soft factors. Complexity stands in detail for the challenge of technical implementation, needed effort for preparation and facilitation, and sophistication of the didactical design.

Content delivery to a mobile device (free context) is technically and didactically relatively incomplex. Classroom response systems (formal context) are technically somewhat more complex, mainly because of the groupware functionalities. The meaningful integration of such systems in a traditional educational setting needs some thoughts and adaptions. However, because of the face to face situation, control there is very high and thus moderation does not need much consideration. In a digital context almost all interactions need to be facilitated and supported by a computer device, so the technical challenges are rising. An educational design in a physical context (e.g. museum) is likely to require challenging technology (e.g. location based services. groupware etc.). The moderation, providing of orientation, interaction, and the preparation of the environment requires much effort and many thoughts. This challenge is even stronger in informal context because of the additional dimension of social skills, values and emotions.

On the ordinate the categories are sorted by educational ambition. Educational ambition starts from behaviourist and teacher-centered learning on the bottom, passing constructivism, socio-cognitivsm and ends up with informal, learner-centered learning on the top. Details if situated learning is more ambitious than informal learning might be discussed, but the general idea and trend of the classification should have become clear by now. The chart shows the potential, likeliness and expectation of the categories being more learner-centered the upper they are situated. However, there is no automatism as for instance learning in physical context could still be teacher centered (e.g. guided tour in a museum). In such a case the chart is useful to detect, visualise, and point such misconception and helps to correct it.

The suggested classification for mobile learning does not only classify projects, but also helps in aiming their further development. MGame [GHS04] is clearly classified as physical context. But using the chart, the author found the earlier prototypes of MGame to be too restrictive and teacher-centered. Fresh students needed to solve tasks on a campus in order to explore the university. The allocation of tasks, their allocation among the participating teams and the order when to solve what task was strictly [vorgegeben] by the application. This did not fully satisfy the original idea of explorative learning. There are more examples, how a consultation of the chart would lead to a better exploitation of the potentials of mobile learning in other projects and straighten further development. An application that trains literacy any time and anywhere like in m-learning (now free context) could be inspired by elements from other contexts, e.g. physical context. Then the words and phrases to be trained would be adapted to the current environment, i.e. a person in a restaurant would learn the name of meals and how to order. The link to physical context would help to improve learning efficiency and motivation. A simulation game like Savannah (now digital context) could try to embed the physical environment in the game in order to inspire imagination of the players. A street would become an unpassable, dangerous river in the digital world and a basin were a source to satisfy thirst. With a step further towards informal context, Savannah would be played longitudinal over days or weeks, integrating many real situations from everyday life in the virtual reality of a lion and vice versa. Such learning in analogies could be used to reflect interpersonal interactions.

4 What we miss in Mobile Learning

Mobile Learning is still a very new field in education research. Within the last few years there has been spent a lot of effort in various activities to learn about the dynamics, barriers, potentials, and benefits. We are in a phase of divergence, i.e.

	Projects included in this paper	**Projects found altogether**	**Estimation for further projects**
Free Context	9	50	very many
Formalised Context	3	23	several
Digital Context	12	13	few
Physical Context	17	28	dozens
Informal Context	4	8	very few

Tabelle 1: Distribution of mobile learning projects across the context types

Table 1 shows the distribution of collected mobile learning projects across the categories. By far the most attention in mobile learning is drawn by free context [All05, pg.1]. The educational complexity there is low, wins are cheap, results come fast and it is typical for digital innovations that they are technology driven during the early phases. Anyway it is time now to shift more focus towards the more demanding categories in order to crack the real benefits of mobile learning.

The relatively high frequency of occurence for projects in formalised context is amazing, because the wheel has been reinvented many times there. Mobile classroom response systems are by far the best investigated systems and tons of data have been ascertained. The main reason for this might be found in the link between research institutions and access to learners in formal teaching (i.e. students at universities in lectures). The time has come to consolidate the available knowledge, leave the research phase and build commercial products and develop trainings.

There is only a very small number of research groups, who deal with participatory simulations. Such systems with digital context lack didactical and methodical flexibility. Simulations are developed for one very specific learning goal and can hardly be transferred into any other setting or be used for any other purpose. It seems not efficient for a normal teacher to become acquainted with the system, the technology, or the different pedagogy, just to teach children in a fun way, how a virus spreads. Digital context is in danger to run in a dead end street, if there is no further benefit, except the higher fun-factor of moving physically. The digital context needs to be extended by and melted with physical or informal context.

Physical context is supposed to be clearly learner-centered, if the learners were dismissed to make their own experiences, explore the environment, set their own focuses, gain knowledge on their own, and cooperate with other learners. Learner-centered settings are challenging, because they must still be managed, scaffolded, and moderated, so learners do not lose orientation and the learning remains coordinated. But the teacher is bereft of physical control, when learners are leaving the techer's presence sphere. The balance between

dismissing learners, but keeping processual control can hardly be optimal in mobile physical context settings. Mobile technology has a high potential to support this management function in mobile settings, leaving a much higher flexibility, spontaneity, and ad-hoc adaptability than analog settings. In fact most projects classified as physical context still trust very much on tight physical control and thorough preparation of the learners. For instance the butterfly watching system does not support pupils to investigate butterflies' life after school on a meadow, but runs organised during a limited time frame on a butterfly farm [CKJP04, pg.7]. The same phenomenon can be found in almost all other current projects. This potential of mobile learning has obviously not been discovered yet.

Learning in informal context is another omitted chance of mobile learning, to add value in education. Nowadays there is only limited interpersonal support for say people to lose weight, or people who would like to change habits, or train personal skills. Online desktop communities support at best reflection long before and long after action, but there is hardly any systematic support for individual and cooperative reflection in action or immediately before and immediately after action. There is no noteworthy systematic support yet for mutual awareness, coordination, or facilitation of mobile learning communities.

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