# Human-Computer Interaction for Mobility and Learning

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**ABSTRACT**
Contextual learning activities supported by mobile devices are designed to include some kind of interaction with the physical environment. However, students may place the mobile devices in the foreground of interaction rather than interacting with the physical environment. We understand this as a problem of human-computer interaction, or more specifically of human-device interaction. This leads to the research question: How do we design for contextual learning supported by mobile devices? We approach this question from a design-based research perspective, where we design and evaluate contextual mobile learning activities together with teachers and students in four iterations. The contributions of this thesis are (1) a review of contextual mobile learning research, (2) a conceptualisation of contextual mobile learning from the perspective of human-device interaction, and (3) a model of human-device interaction that can be used in designing contextual mobile learning activities.

**Author Keywords**
Human-Computer Interaction, Design-Based Research, Mobile Learning

**INTRODUCTION**
The main reasons for introducing mobile devices to learning activities outside the classroom is that it enables new learning experiences, since it can place learning in authentic contexts, support peer collaboration, and motivate learning (Wijers, Jonker, & Drijvers, 2010). Simultaneously, one challenge of introducing mobile devices to learning activities is that the novel technology might detract from the new learning experiences (see *Figure 1*). This is the challenge focused upon in this thesis. We approach this challenge from a human-computer interaction perspective, where we arrive at a model for designing formal learning activities outside the classroom through an iterative process of design and analysis.



*Figure 1: Student interacting with a mobile device in an outdoor environment*

**MOBILITY AND LEARNING**
In the research field of mobile learning many different research traditions are coming together. These traditions bring different understandings of what is meant by *mobility* and by *learning*.

Frohberg (2008) presents four different views on mobile learning, where concrete mobile learning projects may be related to more than one of these views. In the first view, mobile learning is about accessing learning material from anywhere, for example on the bus. The mobile device is what makes this possible and learning is understood as transfer of information.

In the second view, it is the learning environment that is mobile. In this view we find games for learning, run on mobile devices. The learning tasks are either open ended or structured, with either not defining what is meant by learning or by relying on formal learning. As the learning environment is mobile in this view, no other media than the mobile devices are needed.

In the third view, it is the learner that is mobile. This view is about moving outside the classroom, to another physical environment where the understanding of learning is dependent on this physical environment. The role of the mobile

technology is to allow the learner to connect with the physical environment, for example by using sensors. In the last view, the learning community is mobile. The mobile technology is used for accessing and creating a common learning environment, which means that learning is seen as co-created.

This paper is framed within the third view where the learner is mobile, more specifically the learner is mobile primarily in the physical environment. For this view of mobile learning we adopt the concept of contextual mobile learning.

### Contextual Mobile Learning

Brown et al. (2010) describe location-based and contextual mobile learning as learners being continually mobile: "Rather than seeing learners as physically present in a certain place, such as a classroom or a museum, learners are active in different contexts and frequently change their learning contexts." (p. 3). Learners are mobile in the physical environment, however from looking at previous projects we see that it differs to what extent the physical environment is integrated in the learning activities. From a review of mobile learning research projects (Frohberg, Göth, & Schwabe, 2009) complemented by the review by Brown et al. (2010) we identify previous projects where learners are mobile in physical environment. These are projects where the physical environment is used as a backdrop, like Savannah (Facer et al., 2004) where children learned about lions by playing lions on a virtual savannah. There are also projects that uses objects in the physical environment, like MyArtSpace (Vavoula, Sharples, Rudman, Meek, & Lonsdale, 2009) where children could collect virtual items in a museum. And there are projects that integrates the physical environment to a large extent, like Ambient Wood (Rogers et al., 2004) where children explored a physical environment that had some added digital properties, as for example you could listen to photosynthesis in trees. Two recent projects focus on mathematics outside the classroom. These are MobiMaths (Tangney et al., 2010) and MobileMath (Wijers, et al., 2010), with low to medium integration of the physical environment.

The learning activities on geometry reported on in this thesis have a medium integration of the physical environment.

### RESEARCH MOTIVATION

The review paper by Frohberg et al. (2009) reports that roughly one third of mobile learning research projects strive to move learning away from the classroom to more natural environments. In the same review paper the authors noted that there is "very little work which discusses the placement of mobile tools as means of control" (p. 318) and that "[v]ery 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." (ibid, p. 318). As noted in these research projects the field trials are done with small groups of students to facilitate collaborative learning. Some of these projects use mobile devices to not only present information about tasks to users, but also to control the flow of the learning activity in detail. This type of design is related to device-centric approaches that lead small groups of learners to place the mobile devices in the foreground of interaction, at the expense of their social interaction and interaction with the environment. It is notable that mobile devices in the foreground of human interaction are just reported on in peripheral notes in research reports from these projects, and consequently what it means that human-device interaction is in the foreground in contextual mobile learning activities is seldom questioned or understood as a main research problem (Göth et al., 2006).

### Related work

A few projects have explicitly addressed the problem of mobile devices in the foreground of interaction. Cole and Stanton (2003) compares projects they have been contributing to; KidStory, Hunting the Snark and Ambient Wood, and report that the students had problems focusing on anything else but the mobile device. Their analysis showed that the problem was that the device was displaying a continuous flow of information and their solution was to deliver information only occasionally.

Hsi (2003) reports from observations on a mobile museum guide that there is a risk that the learning opportunities offered by the physical space is turned into "'heads-down' one-way transmission of information via a tiny display" (p. 317). The solution offered was careful instructional design. In the project Caerus (Naismith, Sharples, & Ting, 2005) focus on the mobile tourist guide was reported to be a problem, with "a large amount of 'heads-down' interaction" (p. 58). Rethinking implementation and investigate both technical and non-technical navigational aids were the suggested solutions.

Göth et al. (2006) report on a campus guide called the Mobile Game that: "In the current version of the MobileGame the focus of the players is permanently on the device." (p. 159). They suggest the following five solutions: plan for discontinuous usage, plan focus switches, use technologies only if it brings added value, do not use animations if the application is in the background, and reduce features as much as possible. In a follow-up study Göth and Schwabe (2010) redesigned the automatic updates of screen contents to students manually pushing an update button. The change resulted in a marginal improvement in how much the students were distracted by the device.

This review of related research work suggests that mobile devices in the foreground of students' interaction is a problem that is noted by other researchers. However, with one exception the solutions suggested are not elaborated. In the only exception, Göth et al. (2006), the suggested solutions are not implemented and in the follow-up (Göth & Schwabe, 2010) the evaluation resulted in only a marginal improvement.

## RESEARCH QUESTION

Contextual learning activities supported by mobile devices are designed to include some kind of interaction with the physical environment. However, students may place the mobile devices in the foreground of interaction rather than interacting with the physical environment. We understand this as a problem of human-computer interaction, or more specifically of human-device interaction. This problem leads to the research question: *How do we design for contextual learning supported by mobile devices?*

## RESEARCH GOAL

- Contribute to a conceptualisation of contextual mobile learning from the perspective of human-device interaction.

- Develop a model of human-device interaction that can be used in designing contextual mobile learning activities.

## RESEARCH METHOD

In collaboration with a local primary school we have developed a design of a contextual mobile learning activity in four iterations; with one iteration per year. The first two iterations were framed within a project on geometry followed by the last two iterations within a project on biology (*Figure 2*). In all four of the design iterations we worked together with teachers and students in developing and refining a sequence of learning activities supported by mobile devices.
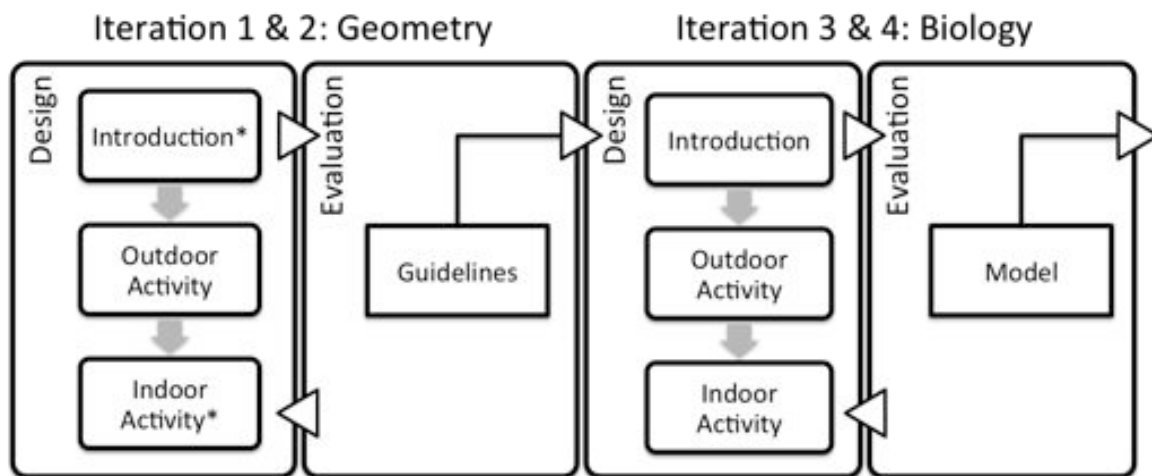


*Figure 2: Research process (\*: introduction was not part of the first iteration and indoor activity was not part of the second iteration)*

In approaching the research questions we designed and implemented contextual learning activities, by adopting design practices from design-based research (Design-Based Research Collective2003), where we relied on co-design (Penuel, Roschelle, & Shechtman, 2007) for the design iterations (see *Figure 2*). By design practices we refer to working in iterative cycles together with teachers in creating a sketch and later a prototype that can be tested and eventually deployed in schools. The Design-Based Research Collective (2003) discusses design research in education and states that "[t]he challenge for design-based research is in flexibly developing research trajectories that meet our dual goals of refining locally valuable innovations and developing more globally usable knowledge for the field." (p. 7). The Design-Based Research Collective (2003) argues that design-based research blends empirical education research with the theory-driven design of learning contexts. Design-based research has proven a suitable methodological approach for the field of mobile learning, since design-based research attempts to combine the intentional design of interactive learning contexts with the empirical exploration of our understanding of these contexts and how they interact with the individuals (Hoadley, 2004). Design-based research follows an iterative cycle of identifying, developing, building and evaluating similar to that of interaction design processes. *Figure 2* shows the design-based research process as design and evaluation phases, where the outcome of the activity design (introduction, outdoor activity and indoor activity) is shown for the design phase and the outcome of guidelines or a model is shown for the evaluation phase.

## ANALYSIS AND PRELIMINARY RESULTS

The analysis relied on different methods. Initially we used interaction analysis (Jordan & Henderson, 1995) where three researchers that had been part of the data collection in the field worked together on recorded video and audio material. In the first iteration we used the analysis foci suggested by the method (Eliasson, Spikol, Cerratto Pargman, & Ramberg, 2010) and in the second study we used the analysis foci related to mobile devices in the foreground of interaction. In the second iteration we added a more detailed analysis of the video episodes where the students' visual focus on devices was especially strong and episodes where it was notable that focus on devices was absent (Eliasson, Cerratto Pargman, Nouri, Spikol, & Ramberg, 2011). In the third analysis we transcribed interaction with devices from video data and mapped the transcription to a model of six categories of interaction we suggested (Eliasson & Knutsson, 2012). The result was a concrete measurement of to what degree the students interacted with the devices and the physical environment in the

ways intended in the design of the activity (Eliasson et al., 2012). In the fourth iteration we will analyse transitions between interaction with devices and interaction with the physical environment by comparing two conditions: students identifying species of trees by using QR codes and by not using QR codes. The QR condition was designed using our model of human-device interaction. Thus we hope to see more than just marginal improvements in the QR condition over the non-QR condition.

## DISCUSSION OF CONTRIBUTIONS

The contributions of this thesis are (1) a review of contextual mobile learning research (2) a conceptualisation of contextual mobile learning from the perspective of human-device interaction and (3) a model of human-device interaction that can be used in designing contextual mobile learning activities.

The contribution of the model is different from other approaches in that it is developed through a design-based research approach focusing specifically at the problem of human-device interaction in contextual mobile learning. Our model is better tested than other approaches since it is evaluated empirically through design iterations and field tests with students.

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