

## Is Learning Really a Phone Call Away? Knowledge Transfer in Mobile Learning

Allan Knight, Monica Bulger, Kevin Almeroth  
University of California, Santa Barbara

### Abstract

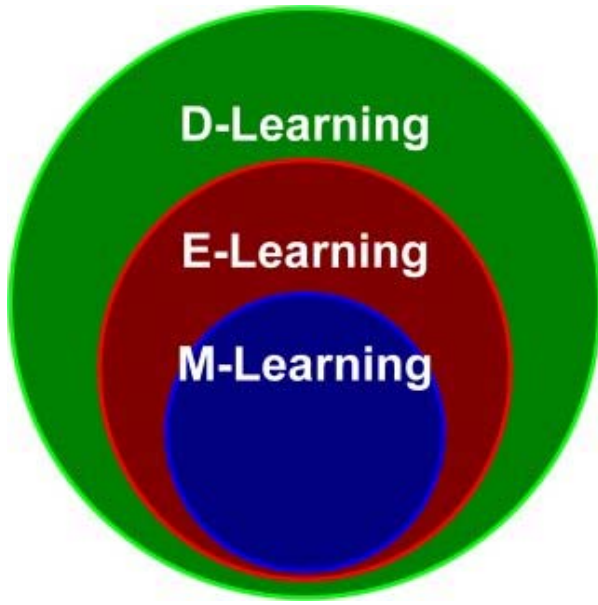
Mobile learning can positively contribute to the development of learning communities by providing communication options that span contexts and locations, are available whenever, and are used virtually everywhere (Alexander, 2004; Sharples, Taylor & Vavoula, 2005). At UC Santa Barbara, we are currently conducting a campus-wide study that examines whether students' use of technology, both within and beyond the classroom, correlates with academic performance. While we primarily concentrate on the use of course websites accessed with non-mobile devices, we have begun to use a Performance-Based Feedback System (PBFS) to explore (1) how to extend the instructor-student feedback loop beyond the traditional classroom setting, (2) how knowledge transfer can be accomplished using mobile devices, and (3) what technical challenges must be overcome. In this paper, we examine ways that mobile networking technologies can foster the creation of learning communities and provide new methods for studying knowledge transfer.

## Is Learning Really a Phone Call Away? Knowledge Transfer in Mobile Learning

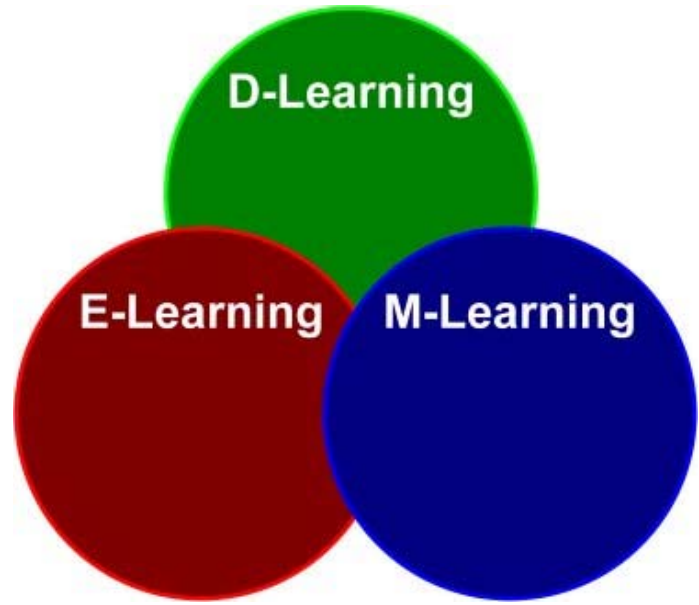
For over a decade, instructors and educational researchers have identified the necessity of creating learning communities both within and beyond their classrooms (Flower, 1989; Gee & Green, 1998; Lave & Wenger, 1991). Ideally, learning communities promote deeper understanding of the classroom material through discussion and experiential activities. As with other areas of education, the challenge in developing these groups lies in fostering authentic activities that empower members to actively formulate and communicate their understanding of the materials. Emerging classroom technologies enhance the development of these learning communities by extending interaction beyond the classroom (Knight, Almeroth, & Bimber, 2006).

While the traditional model of knowledge transfer considers only instructor-student or text-student interactions, the social-constructivist approach offers a more flexible model conducive to mobile learning: peers learn from each other and through their interactions with resources across multiple modes and contexts (Mayer, 2001; Jonassen, 1996; Jonassen, Peck, & Wilson, 1999; Sharples, Taylor & Vavoula, 2005). To study knowledge transfer, then, we must examine the visible interactions between students, instructors, and resources as well as the meta-knowledge transfer that occurs between mobile devices and learning management systems.

In this paper, we use a Performance-Based Feedback System (PBFS) to examine how knowledge is shared, accessed, and revised among student learning groups in face-to-face learning environments as well as in distance-learning scenarios. We propose extending this model to mobile learning studies by first determining whether students are interacting using mobile devices and then developing a method for assessing this



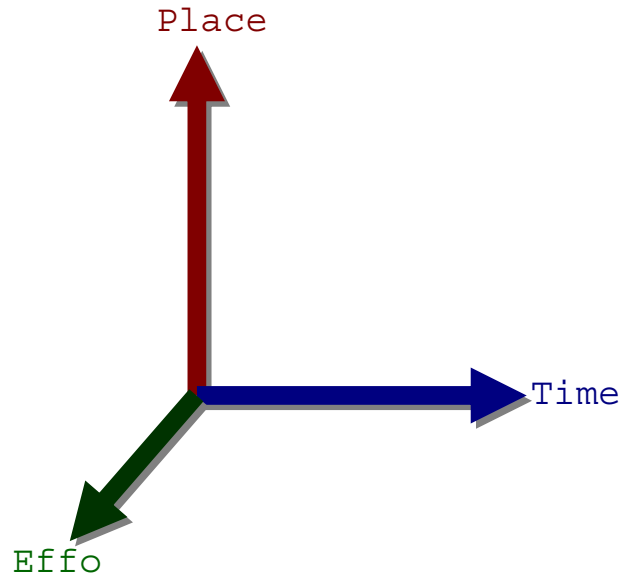
*Figure 1. Popular perspective of learning techniques*



*Figure 2. The MLearn Community Perspective*

interaction. Mobile learning devices present a major technical challenge because they are not always connected; however, by leveraging existing mobile technologies such as ??, data such as what types of technologies students use in educational settings and when they use them can be collected. Once this data is collected and analyzed, we can build an understanding of how students use mobile devices and then tailor lessons to support and enhance this use. By integrating content development with data collection, we thus create a reflexive feedback model in which we identify, develop, test and refine pedagogically sound methods of using mobile technologies.

Understanding the ways students interact with technologies in learning contexts is a key first step to integrating mobile content and technologies in educational settings. To contribute to the ongoing assessment of mobile learning, we propose a methodology that uses a PBFS to study mobile learners and their mobile devices.



*Figure 3. Our perspective of learning techniques*

### Perspectives on M-Learning

First, the popular misconception that the relationship between m-learning and both d-learning and e-learning is best expressed in terms of set theory. In this perspective d-learning is viewed as super set of all three paradigms with e-learning being a proper subset of d-learning. In other words, all instances of e-learning are also instances of d-learning. Similarly, m-learning is a proper subset of d-learning, and therefore all instances of m-learning are also instances of e-learning. Figure 1 illustrates this popular idea of their relationship. The MLearn community, however, takes a slightly different view of these relationships. Rather than viewing them as proper subset, the community correctly views them as three overlapping sets. In this view none of the sets are a proper subset of each other, but each set does slightly intersect with each other set. Figure 2 illustrates this perspective.

We, however, take a different approach to categorizing teaching techniques. Rather than arbitrarily assigning each technique to d-learning, e-learning or m-learning, we look at teaching practices in general in terms of 3 axes as shown in figure 2. The first axis represents place. Locations at the origin represent learning that takes place with no spatial displacement from the classroom. Moving further up the axis represents larger and larger spatial displacement and therefore learning taking place further from the traditional classroom. The second axis represents temporal displacement. Here, the origin represents no temporal displacement from a fixed class meeting time. Locations further from the origin represent temporal shifts from the agreed upon class meeting time. By varying different learning experiences along both these axes, instructors can provide learning experiences at a greater number of times and places. All three of the learning paradigms, d-learning, e-learning and m-learning, are really achieved by varying the learning experience along these axes. The advantage of this organization is that it avoids the natural arguments that result from trying to classify specific teaching techniques. Is a book really an m-learning device? Is a PDA in the classroom really m-learning? With the popular view, and even the research view of learning, these questions are not easily answered and open to much debate. However, by using the axes to organize teaching techniques, the only concern is how much time and space are shifted for a particular learning experience. Finally, the third axis in Figure 2 represents effort. This axis measures how much effort is required to achieve a learning outcome by both the instructor and the student. In some cases the amount of effort required to implement a specific learning technique is not worth the benefits gained. Other techniques may require a small amount of effort in the beginning that results in less effort on the part of the

instructor or the student. The goal of the Course Management System (CMS) is an example of the instructor exerting an initial effort that results in less effort required by students and instructors to gain access to course material.

Currently, most courses are taught using techniques that fall in a variety of locations on these axes. Some teaching is done in the traditional classroom at a fixed time, which would appear at the origin of both the temporal and spatial axes. Other tasks may be done outside the classroom at any given time before a deadline. The goal then as educational and technology researchers is to find the position on these axes that maximizes the outcomes for students and instructors.

### Related Work

In the following we describe three architectures created specifically for mobile learning environments. These pieces of research, while not exhaustive, represent the central themes of m-learning architectures. Each of the architectures contains modules for content management, presentation management and context awareness. Content management is the management of the learning objects themselves and provides for access to the various formats of the objects to the students. A pre-existing CMS from an e-learning environment generally provides this functionality. Presentation management refers to the modification of learning objects based on what device the object is accessed. Finally, context awareness refers to how, when and where an access of a particular learning object occurs. Context awareness, discussed in greater detail later in this paper, is the main focus of our research. Again, however, our work is not architecture, but rather a suggestion of an addition to all architectures especially in how they act upon their context awareness.

We first present Mobile Learning Management System (m-LMS) (Trafinova, & Ronchetti, 2004). The m-LMS provides the aforementioned modules as “Context Discovery”, “Mobile Content Management and Presentation Adaptation”, and “Packaging and Synchronization”. The m-LMS architecture is in reality an adaptation of an e-LMS to support m-learning. The e-LMS still handles the management of learning objects, however, in order to display these object properly the mobile device receives a modified version. In addition, the context discovery module helps to transmit the proper learning object to the mobile device based on the current context. The m-LMS architecture is similar to our work in that it seeks to guide students towards downloading the most appropriate material. The m-LMS architecture does not, however, inform the students of the importance of certain learning objects. Instead it merely downloads the most important learning objects to the mobile device.

Porta-bile(Colazzo, Molinari, Conchetti, & Trifonova, 2004) is the second architecture presented here and is similar in focus to the m-LMS project above. The focus is, again, the transformation of a learning management system primarily used for e-learning into an m-learning architecture. By building a web application on top of a pre-existing LMS using web services, their e-LMS is transformed into an m-LMS.

Finally, we present the architecture called Open Mobile Access Abstract Framework (OMAF) (Lonsdale, Baber, & Sharples, 2003). The work is part of a greater effort, called MOBILearn, to observe the practicalities and effectiveness of mobile learning in general. This work presents a layered approach to m-learning architectures. The main difference between this work and the others mentioned above is that OMAF



represents an overall abstraction of how to design mobile learning environments, rather than actual architectures.

While all the above research has a common goal, which we share with them, of measuring the effectiveness of various mobile learning technologies, we believe there are two main deficiencies. First, with the exception of MOBIlearn, these research projects treat mobile learning as a proper subset of e-learning. We believe that there exists m-learning opportunities that do not exist in e-learning. The second problem with these projects is their idea of context. For each, context refers to the temporal, spatial and hardware contexts. Our work would prefer to extend the idea of context to include the performance of the student using a particular device and the performance of others with respect to a particular learning object. By extending the context to include performance, we believe that the mobile learning experience can be enhanced further to allow the students to more likely access the learning objects that have a greater impact on their performance.

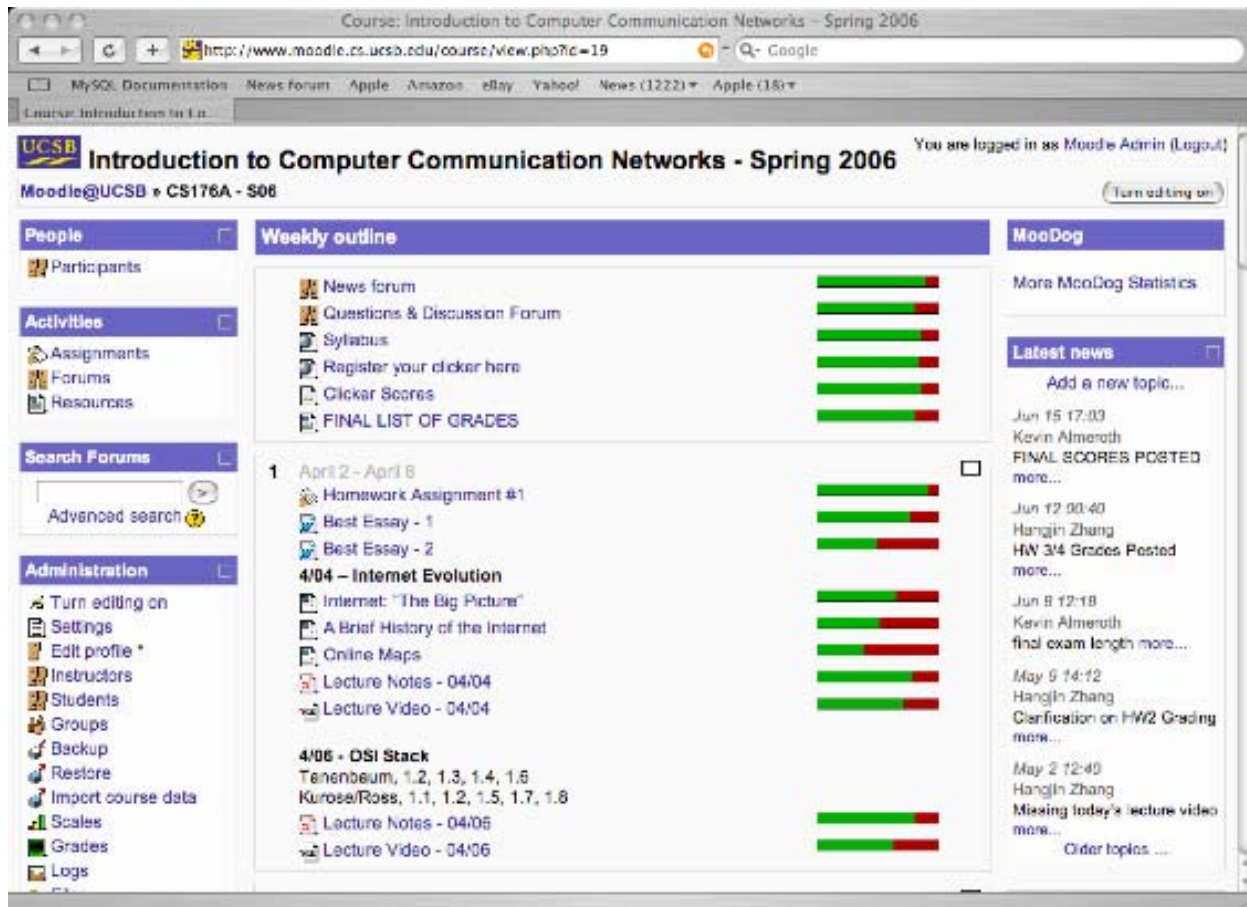


Figure 4. Screen capture of the Moodle extension MooDog. The red and green bars convey access information about learning objects.

## Performance-Based Feedback Systems

The goal of our research with Performance-Based Feedback Systems (PBFS) is to introduce the feedback loop, much like that from a traditional classroom, into the d-learning, e-learning and m-learning environments. For example, if a student has not yet read a homework assignment that is due in the near future, the PBFS, as currently constructed, would e-mail the student a reminder that the assignment is due and that they need to read and start the assignment. While this scenario is currently possible with

current most CMSs, the time required to achieve such feedback is prohibitive. Analyzing the logging information of the Course Management System associated with a particular course make these scenarios possible. The hope is that by ‘reminding’ those students who have not kept up with the material and by keeping the instructor informed about these students, the overall performance of the students is improved. We have already begun to build and use such a system for Moodle. The MooDog extension for Moodle provides feedback to both student and instructors regarding how often learning objects have been accessed. Figure 4 above is a screen shot of MooDog.

The word “Performance” as used in our work has several implications. Primarily, the word refers to our goal of improving overall academic performance. Secondly, “Performance” refers to the fact that performance of past and present students in a given course can be used to determine which learning objects are important to a course and what sort of interactions students have with these objects. Going back to the homework assignment example, it may be important to know how long before an assignment is due should a student begin, or at least read, an assignment. More importantly, does this time gap matter in the overall performance on that particular assignment.

To implement a PBFS requires three actions: Collection, Analysis and Presentation. The collection action has two distinct sources, the CMS system, which keeps track of learning object accesses and student information. The student information is necessary at this point to help us understand what factors truly impact their educational experience. This data allows us to differentiate between true enhancement of the learning experience and difference in Performance-Based on other background information such socio-economic status. The analysis actions use both types of information. Analysis

refers to the actual manipulation of data to determine an action for the PBFS. For example, if the PBFS observes that a particular student has not accessed a learning object associated with an upcoming assignment. The PBFS may then decide to inform that student that the assignment deadline is approaching and accessing the learning object may greatly affect the student's performance on that assignment. Analysis is also currently ongoing to determine the exact importance of viewing different types of learning objects. This analysis seeks to determine such metrics as how long before an assignment is due should a student read the assignment and presumably begin work on it to maximize performance. Similarly, this analysis seeks to determine which types of learning objects are the most effective. Are PowerPoint slides more important the student forums? Or is the opposite true? Finally, the presentation action notifies both the students and the instructors about accesses statistics of learning objects. The forms of these presentations can be e-mails in the case of students, and web pages with viewing statistics for both students and instructors. Figure 3 illustrates Moodog's presentation of access information for instructor use.

#### *Performance-Based Feedback Systems in an M-Learning Environment*

At the present time, our work primarily concentrates on e-learning environments. Recently, however, we have begun to look at how our work can complement m-learning environments. In looking at this new area, we realized integration into an m-learning environment would also enhance a PBFS. A PBFS in an m-learning environment creates more opportunities for collecting data. Better data collection is possible because mobile devices tend to be more application specific. For example, trying to surmise how much time students actually spend reading the content provided on a course website is difficult

to measure accurately, especially when viewed on a PC. Measuring time spent interacting learning objects on a PC is problematic in e-learning environments because PCs are capable of running several applications at once. On mobile devices such as PDAs or cell phones, which are less multipurpose, the possibility exists to more accurately collect data on learning object usage. This aspect of m-learning environments is, in our view, an important enhancement to the collection and analysis of performance data that will lead to even better measurements for the feedback system.

### *M-Learning with Performance-Based Feedback Systems*

Most m-learning environments that we have read about involve some form of context awareness. The content, in the form of learning objects, is in some way modified, and/or selected, based on the temporal and spatial positions of the user and the hardware restrictions of the mobile device in use. The context of a request from a mobile device is the combination of these three characteristics, and maybe some others. One dimension of context missing, however, is what observed behaviors are associated with a particular learning object. For example, when, if at all, did the student access a learning object. This information is very important when selecting which objects to upload to a mobile device. Proper selection of learning objects for transmission to a mobile device is important because mobile devices are, by definition, limited in their resources. For example, in a situation similar to that given in *Portable*, where a student is at the library around the deadline of an assignment, an m-learning environment may decide to transmit learning objects related to a talk at the library, but not inform the student of the impending deadline for an assignment. If the student has already viewed and/or submitted the assignment, then the original choices seem appropriate. If, however, the student has not

then the choice may not be optimal. This example is one of many where including student interactions with learning objects can result in better selection of materials to upload to the mobile device.

How then is the information necessary for proper feedback collected? If the mobile device is connected, traditional collection methods are appropriate. The CMS collects the requests and records them in a log. If, however, the mobile device lacks connectivity, then the data must be collected locally on the mobile device and forwarded to a central collection server in the future. This collection of data poses the main technological challenge for combining m-learning and a PBFS.

There exist several techniques for overcoming this challenge. If time is not important, then the collection server can download the information upon the next connection. If, however, time is important then other technologies may be necessary, such as those employed by delay tolerant networks, or by simply notifying the user that connectivity is required at the soonest possible time. Also important and of concern is when data collected offline consumes the limited resources of a mobile device. If connectivity does not occur in a timely manner, the data collected may accumulate to the point of using all available resources on the mobile device. By eliminating some information in the data collection, perhaps the oldest or least important, the mobile device can avoid consuming the limited resources available to it and upload the remaining information when connectivity becomes available.

### Summary and Conclusion

In this paper we have discussed both Performance Feedback System (PBFS) and m-learning both as independent entities and when used in conjunction with each other. A

PBFS is a powerful tool to help students improve their performance in a class. Similarly, m-learning is an important tool for both improving the learning experience in traditional classrooms and making learning possible where it was not before. Their combination, however, enhances both. Allowing a PBFS more opportunities to collect usage data and with greater detail will help it make better choices about which objects to notify students and instructors about. M-learning, too, can benefit from incorporation of a PBFS. The additional dimension that a PBFS adds to context awareness will greatly improve the decision making process for any m-learning architecture. For the future, the combination of these two concepts will allow for better measurement of performance in class and a better experience in general.

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