Creating a Powerful Learning Environment with Networked Mobile Learning Devices

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Creating a Powerful Learning Environment with Networked Mobile Learning Devices

The last 5 years have witnessed a tremendous proliferation of mobile computing devices in both the consumer and education markets. The education community is still in the process of discovering which mobile technologies, use models, and implementation configurations will confer the greatest learning return on investment. Many studies of one-to-one computing have been undertaken as researchers and practitioners investigate the benefits and impacts of personal and mobile computing for learning. Such research is more important than ever, as increasingly the education community requires that educational technology investments be targeted to uses shown to have a real impact on learning.

In this article I argue that one way to ensure that mobile technology in schools has real impact on learning is to design mobile technologies to support instructional practices that have been demonstrated through prior research to improve learning. This should be done in a way that leverages the specific affordances of networked mobile devices to make it easier for teachers to implement high-value instructional practices. This will make it much more likely that learning will be enhanced through teachers' and students' use of the technology. I present a rationale for mobile technology integration to support formative assessment and to enhance feedback during classroom activity. I also present a vision of a near-future classroom in which networked mobile computing devices enable teachers and learners to create a powerful classroom learning environment that is personalized and rich in information, feedback, and interaction. Finally, I argue that the classroom technology infrastructure of tomorrow should be designed not just for learners but also for teachers—supporting teachers as high-performance professionals who perform cognitively demanding work in context of a classroom learning *system*.

Technology Supports for High-Performance Teaching and Learning

Design the next-generation classroom technology infrastructure should support instructional practices and learning experiences that have been shown to improve learning. A robust body of research in the learning sciences has demonstrated that two related instructional practices, formative assessment and providing feedback during learning activities, are highly effective instructional strategies—indeed, the most effective strategies yet studied (Wiliam, 2007; Wiliam & Leahy, 2006).

Formative assessment involves teachers' use of information about students' current understandings and skills to guide students' learning toward the mastery of target understandings and skills. It has been shown to be highly effective in improving student learning across a wide range of topics and student populations (Black & Wiliam, 1998; Shepard, 1995, 2000). Both automated feedback provided by software programs and teacher-provided feedback have been shown to be highly effective in improving student learning (Anderson, Reder & Simon, 2000; Bangert-Drowns et al., 1991; Fuchs & Fuchs, 1986; Kluger & DeNisi, 1996). Research on the impact of feedback on learning has also shown that the more closely feedback is integrated into the learning process the greater the benefits of the feedback (Anderson, Reder & Simon, 2000; Kulik & Kulik, 1988).

While both of these instructional practices are highly effective, research has also demonstrated that both are rare (Black & Wiliam, 1998a, 1998b). It's not hard to understand why. First, few teachers are trained in formative assessment strategies. Second, making accurate inferential judgments about student thinking and understanding in real-time to provide feedback during classroom activity generally requires a great deal of skill and knowledge (Ball, 1997; Berliner, 1986; Shulman, 2005).

Finally, teachers' incredibly large workloads and their work conditions can be barriers to the implementation of formative assessment and providing feedback. One study of teachers' time (Swaim & Swaim, 1999) produced a simple calculation that illustrates the challenge of providing individual feedback to students: a secondary school teacher with a typical workload and 50-hour work week will have approximately 10 minutes to prepare for each class and 5 minutes per week for reviewing each student's work on a *weekly* basis, assuming that the teacher teaches five classes and 125 students a day. When feedback is provided, such as scored homework or quizzes, it is available too late to impact learning because it comes after the conclusion of the leaning episode from which it derived and in the midst of a new learning activity (Black & Wiliam, 1998*a*, 1998*b*; Coffey et al., 2005). This misalignment of learning processes and related feedback is represented in Figure 1. In short, in classroom learning, feedback to students is typically too little, too late. Clearly, investment in technology to create a learning environment rich in information and feedback is warranted by the research and has strong potential to improve student learning.

-- Insert Figure 1 about here ---

Networked mobile devices in the classroom enable the *instrumentation* of teaching and learning processes in the classroom. With such technology supports, information and feedback can be available *during* classroom learning activities, greatly enhancing the effectiveness of the teacher and the productivity of students' learning time.

Imagine students interacting with digital content using their personal, mobile computing devices, for example, in completing an individual reading comprehension activity or completing a group laboratory activity. Students' responses and other information about their interactions with learning content can be captured and processed automatically. Easy-to-use information can be presented to the teacher in real time for use in making decisions about how to target and individualize instruction during class or to help a learner or a group of learners make course corrections during their learning activity. In addition, automated feedback can be provided to the learner in real time. For example, as a learner progresses through a set of algebra problems, he can receive feedback on his work and answers in real time, rather than completing a set of problems and finding out a day or a week later that the solution procedure she used was wrong. Figure 2 represents a classroom with networked mobile learning devices in which real time feedback information informs learning and instruction.

-- Insert Figure 2 about here ---

What Would It Look Like in Use?

Here's a description of what teaching and learning tools in this kind of technology infrastructure could look like in use. In a high school algebra classroom, each student has a thin client, Tablet-PC type of device, which can potentially be used in all classes. The students and teacher interact with digital content in the form of Internet-based software services with automated, real-time scoring and feedback.

Camila, a student, has completed homework the previous evening on her personal mobile computing device. As she walks into the classroom, her device transmits her ID and homework set to an Internet-connected classroom server. Her attendance is registered and her homework scored automatically. Almost instantly, all students' homework is scored, and they receive feedback on it. The class's homework results are automatically aggregated and graphically displayed on the teacher's tablet computing device. Ms. Jensen, the teacher, glances at the results and sees that problem numbers 7, 10, and 13 posed difficulties for her students. She reviews these problems at the front of the classroom.

Based on the homework results, Ms. Jensen decides to give students an opportunity to check whether they now understand the concept embedded in these problems. She selects new six problems from her digital bank of problems and sends them to students. Learners work in pairs to solve the problems, doing their work with pen input on their mobile devices, and enter their solutions in a Web form. Their answers are scored in real time, and the teacher receives continuously updated information about students' progress and results.

Camila sends an instant message to Ms. Jensen asking the teacher to check her solution procedures. The teacher brings up Camila's screen on her own device, examines Camila's work, and clicks on a pre-set message to send to Camila: "That's exactly right!" Glancing at her screen, Ms. Jensen sees that another student pair, Pat and Jesse, are still on problem 3 and have entered two incorrect solutions so far. She goes to their table to help them.

Soon, all results are in from most students. Ms. Jensen sees that most students have mastered the concept and are ready to move on. Some students, though, need more time with the problem set. Ms. Jensen asks Camila and her partner, who finished all problems correctly, to work with Pat and Jesse to finish the problem set. Standing in the back of the room with her tablet computer, Ms. Jensen selects and sends out the next activity to the student pairs—the students will do an activity using dynamic linked graphical representations of velocity and position to explore these concepts.

Supporting the Teacher as a Learning System Engineer

One of the main benefits of mobile technologies is personalization. Individualized content can be accessed and used on personal devices, at any time and in any place. Students can easily and seamlessly continue learning activities outside of class. However, the need for individualization in the context of facilitated *group* processes has received less attention in discussions of integration of mobile technology into education. Classrooms are learning *systems*, and systems have emergent properties that are not reducible to individual elements within them (Checkland, 1981). During group learning processes, individual learning trajectories are varied, and each needs to be guided and coordinated with other learning trajectories. Recognizing the needs of individual students and coordinating multiple learning processes in real time is a distinguishing skill of master teachers (Berliner, 1994; Carter, et al., 1986). The cognitive demands and complexity of this task are often under-recognized. Effective design for mobile computing in classrooms needs to take into account and optimize real-time *social* processes in the classroom (Hamilton, Lee, DiGiano, & Labine, 2005). Information about the interaction of individuals with each other and with content can enable the teacher to optimize these processes to improve the overall system and thereby individuals' learning outcomes.

Integrating personal mobile technology into a classroom technology infrastructure can drastically increase a teacher's ability to create a powerful learning system in which all learners can learn better. Design of the classroom technology infrastructure should take into account the full range of teachers' work flow and instructional activities. A networked technology infrastructure can:

- Automate classroom procedures such as taking attendance, checking homework completion, creating more time for learning activity;
- Improve teachers' workflow by automatically scoring homework, quizzes, and essays, making information available almost immediately to inform teaching and learning;

- Generate information about student learning *in real time* by capturing and presenting information about learners' interaction with instructional materials;
- Provide performance support for teachers with the complex, cognitively demanding tasks of teaching, such as diagnosing students' errors and individualizing learning activity for 30 learners simultaneously.

With a mobile computing device such as a thin, tablet-type computing device, information can be available to the teacher in real time, anywhere in the classroom, in the form of easy-to-read graphical displays that support decision making. The teacher can circulate in the classroom and check information about learners' progress any time. This information informs how she groups students, whose desks she visits, and what kind of guidance she provides to students. It enables her to more effectively diagnose what students know and can do, provide feedback to students, and individualize instruction.

Reliable real-time, information about students' learning processes and states enhances teachers' ability to determine what students know and what kind of guidance they need to reach learning objectives. It enhances teachers' ability to individualize instruction, and to engineer and optimize learning processes in a way that optimizes the learning processes for learners who are interacting. Another way of personalizing learning is having the right learners interact with each other at the right time. Pairing a learner who needs an extra challenge beyond the assigned task with a learner who needs some tutoring on the assigned task enhances both students' learning experience. With real-time information about students' learning processes, the teacher can effectively orchestrate these kinds of rich learning interactions. Doing this for 30 students simultaneously optimizes the learning environment for all students and enhances the *cognitive density* of the learning system (Crawford et al., 2004).

Supporting teachers' ability to engineer a powerful learning environment thus requires providing both work flow support, through automation of administrative chores during class (attendance, checking homework) and outside of class (scoring homework and quizzes), data capture, and decision support to enhance formative assessment and feedback to students. In the classroom narrative above, even though students have personal computing devices and individualized content, the teacher plays the critical role orchestrating students' interaction with content and in providing carefully adjusted instruction during class time. *Teachers*, not technology, engineer classroom learning environments and mediate and orchestrate students' engagement with learning materials. Therefore, creating a high-performance classroom requires designing a technology infrastructure that supports teachers, the art of teachers, and makes it easier for teachers to do hard things well.

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FIGURES

Figure 1. Misaligned feedback cycles in the traditional classroom.

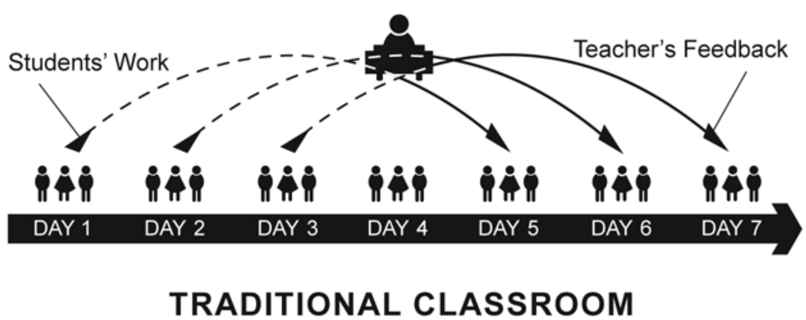
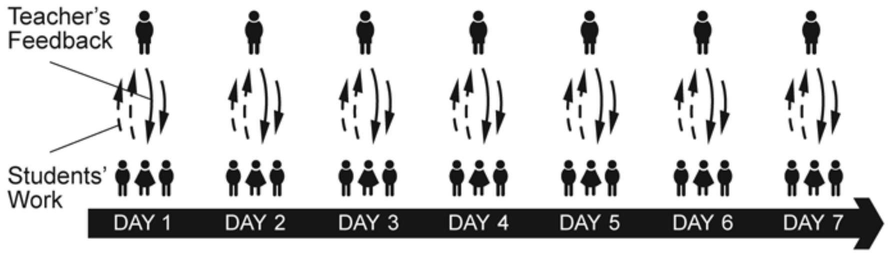


Figure 2. Real time feedback cycles in the instrumented classroom.



TECHNOLOGY WITH DIGITAL CONTENT