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Where is the learning in mobile technologies for learning?☆

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ABSTRACT

Mobile technology – such as tablets, cell phones, and wearable devices – has the potential to play a useful role in promoting academic learning. This potential motivates this special issue on "Mobile Technology, Learning, and Achievement: Advances in Understanding and Measuring the Role of Mobile Technology in Education" edited by Matthew L. Bernacki, Jeffrey Greene, and Helen Crompton. Research on learning with mobile technology should focus on three research questions: Do students learn academic content better with mobile technology than with conventional media (media comparison question)? Which instructional features afforded by mobile technology cause learning (instructional method question)? Under what conditions do students learn academic content better with mobile technology than with conventional media (boundary condition question)? A research agenda is proposed.

1. The case for learning with mobile technology for learning

How can mobile technology – such as tablets, cell phones, and wearable devices – play a useful role in education? This is the question that motivates this special issue on "Mobile Technology, Learning, and Achievement: Advances in Understanding and Measuring the Role of Mobile Technology in Education" edited by Matthew L. Bernacki, Jeffrey Greene, and Helen Crompton. Bernacki Greene, and Crompton (this volume) show how this issue takes on special significance in light of the proliferation of mobile devices in our society. For example, mobile technology for learning has the exciting potential to support academic learning anywhere and anytime, to offer personalized monitoring and advising, and to enable micro-learning in which students can learn in small bits as opportunities become available. Thus, an important issue for education concerns how we can use mobile technology to support and promote academic learning.

2. Are we asking the right questions?

When we engage in research on learning with mobile technology, we can ask a variety of questions. In this special issue on learning with mobile technology, the authors ask questions such as:

How can mobile technology be used in educational research? For example, Xie, Heddy, and Vongkulluksn (this volume) developed an iPad app called ESM-Mobile, that prompted students to take experience-sampling surveys during studying. One interesting finding based on this mobile technology is a correlation between self-efficacy and behavioral engagement. As another example, Lee, Fischback, and Cain (this volume) used wearable cameras and electro-dermal activity sensors to collect data while students engaged in Maker learning activities in an afterschool program. One interesting finding based on this technology is a correlation between electro-dermal activity and engagement. However, these studies did not provide information about how mobile technology affects learning outcomes.

Do students enjoy using mobile technology? For example, Harley, Liu, Ahn, Grace, Lajoie, Haldane, Wittaker, and McLaughlin (this volume) asked students to learn history content with a mobile app and answer survey questions about their experience. Some interesting findings are that students generally enjoyed using the technology and students' level of enjoyment of using the technology was correlated with perceived success of learning. As there was no measure of learning outcome, it is not possible to determine whether using the app caused improvements in learning outcome.

How do students use mobile technology? For example, Epp and Phirangee (this volume) examined how students used a smartphone-based mobile language learning app in a high school English course. Results showed that students varied in how they used the app, with some using it mainly early in the term and others using later in the term and others using it when encouraged to do so. As there was no control group, it is not possible to determine whether using the app caused

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improvements in learning outcomes.

These are all reasonable questions, but they are not directly related to central issue of how to promote learning with mobile technology. In fact, four of the five papers in this special issue have no objective measure of learning outcome.

3. What are the right questions?

The goal of effective instruction is to cause a change in the learner's knowledge (Mayer, 2011), so the most basic dependent measures in research on learning with mobile technology are measures of learning outcome. Thus, from my vantage point as an educational psychologist, the right questions about learning with mobile technology are core questions about learning outcomes, such as the following:

Media comparison question: Do students learn academic content better with mobile technology than with conventional media? For example, the study by Fabian and Topping (this volume) in this special issue sough to determine whether incorporating tablets in elementary school mathematics classes helps academic learning based on performance on a math test. The main finding was that the groups given tablets and the group not given tablets did not differ on significantly on a math posttest. This is not encouraging evidence for proponents of mobile technology for learning.

As another example, Sung and Mayer (2013) found that students who learned about solar cells from a multimedia lesson presented on an iPad performed just as well on a posttest as students who learned on a desktop computer, but iPad learners reported significantly higher motivation to continue learning. Thus, the advantage of mobile technologies for learning may be in promoting motivation to learn rather than in causing more effective learning per se.

In a more recent study, Parong and Mayer (2018) found that students who learned about the human bloodstream in immersive virtual reality wearing a portable head mounted display reported higher interest and motivation than students who learned the same information as a slideshow on a desktop computer, but performed worse on tests of learning outcome. Similar results were reported by Makransky, Terkildsen, and Mayer (2017) in comparing learning science in immersive virtual reality (IVR) with a portable head-mounted display versus on a desktop computer: students liked IVR better but learned less. In these cases, mobile technology increased liking but hurt learning, perhaps due to increased distraction.

Instructional method question: Which instructional features afforded by mobile technology cause learning? For example, tablets allow students to interact with a science simulation through a touchscreen, whereas conventional desktop computers do not. Pedra, Mayer, and Albertin (2015) taught students a six-step maintenance procedure for a mechanical device through an animation displayed on an iPad that either allowed for interactivity (through dragging movements and zoom-through-pinching movements) or did not. Students who received added interactivity on the iPad reported higher interest but did not show improved learning outcome performance, suggesting that interactivity has effects on affective processes but not on learning processes.

Boundary condition question: Under what conditions do students learn academic content better with mobile technology than with conventional media (or by adding an instructional feature to a mobile learning environment)? Would mobile technology be more effective for certain types of learners (e.g., experienced versus inexperienced learners or boys versus girls), certain types of materials (e.g., learning scientific systems versus mathematical procedures), or certain contexts (e.g., in school or at home). These are the kinds of questions that help establish boundary conditions for the effectiveness of mobile technologies. For example, Makransky, Wismer, and Mayer (2019) found that girls learned better from a science simulation in immersive virtual reality when the onscreen guide was a young woman whereas boys learned better when the onscreen guide was a flying robot. Thus, gender may play a role in how to use mobile technologies for learning.

4. The future of research on learning with mobile technology

This special issue helps us chart a course for future research on learning with mobile technology, based on the three questions explored in the previous section. In this section, I suggest six criteria for future research on mobile technology for academic learning.

1. Focus on learning outcomes. First, we need research studies that focus on objective measures of learning outcome as a primary dependent measure. Self-report measures and physiological measures of affective, motivational, and cognitive processes during learning can be helpful additional measures, but the main focus should be on what was learned.

2. Focus on instructional methods afforded by mobile technology rather than on technology per se. Second, Clark (2001) has made the case that learning is caused by instructional methods rather than by instructional media. Thus, we need research studies that examine the effectiveness of instructional methods that are afforded by mobile technologies.

3. Focus on scientifically rigorous experiments. When the goal is to determine the effectiveness of technology-supported instructional methods, experiments are the best methodological choice (Shavelson & Towne, 2002). Although observational studies have a role in educational research, experiments represent the best methodology for answering the questions listed in the previous section. The primary characteristics of experimental studies are random assignment, experimental control, and appropriate measures (Mayer, 2011).

4. Focus on scientific attitude rather than advocacy. Fourth, rather than beginning as proponents of mobile technology for learning, researchers should take a neutral stance as investigators who take an evidence-based approach.

5. Focus on relevant theories of learning and motivation. Fifth, research should be guided by and contribute to evidence-based theories of academic learning and motivation. Several useful theories are described in the papers in this special issue including Bandura (2001) Social Cognitive Theory, Renninger and Hidi's (2016) Interest Theory, and Davis (1989) Technology Acceptance Model.

6. Use mobile technology as a research tool. Sixth, as exemplified in the papers by Xie, Heddy, and Vongkulluksn (this volume) and Lee, Fischback, and Cain (this volume), mobile technologies can be used to collect data during learning concerning the learner's affective, motivational, and/or cognitive processing. This information can be used to help construct a theory of how instruction affects these processes, which in turn affects learning outcomes.

I will consider this special issue a success to the degree that it helps to align future research on mobile technologies for academic learning with these six criteria applied to the three core research questions about media comparison, instructional methods, and boundary conditions.

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