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Rethinking the Technology Integration Challenge: Cases from Three Urban Elementary Schools

Amy Staples | University of Northern Iowa
Marleen C. Pugach | University of Wisconsin-Milwaukee
Dj Himes | University of Wisconsin-Milwaukee

Case studies of three urban elementary schools were conducted to document the integration of technology given identical resources from a local university's PT^3 *grant. Data sources for this qualitative study included participant observers' field notes and journal entries, school personnel interviews, timeline and chronicle of technology-related priorities and events, and children's and teachers' technology artifacts. Cases were summarized with respect to prior technology context, agents of growth and development, and changes and future directions. The analysis identified three scaffolds that appear to have a significant influence on—and redefine the challenge of—technology integration: alignment with the curriculum/mission, teacher leadership, and public/private roles for technology recognition.*

During the 1990s, schools began spending more money on technology than capital goods (Trilling & Hood, 1999). The rapid growth in the types of available technological tools, paired with the decline in the price of these resources, captivated schools and parents alike, who wanted to prepare their children for a society where learning and employment were increasingly dependent on digital access and expertise. Prior to the 1990s, many schools had computers, perhaps one or two per classroom, but the flood of technology acquisition in the 1990s created a different context and opportunity for learning. Computers, the Internet, and software became increasingly available to more and more students.

The task for schools became that of determining how technology and curriculum would operate to strengthen student learning. Companies offering games, educational software, networking equipment, accessories and the like sprang up overnight, offering a multitude of options from which to choose for teachers and administrators. Acquisition, however, was not the end of the road. Teachers, administrators, and researchers alike were coupling their excitement concerning the possibilities and potential power of technology with the underlying question of whether technology was truly needed or beneficial. Studies began to be conducted that examined the effectiveness of technology use in various contexts. Teachers and schools adhering to constructivist orientations seemed to reap the benefits of technology quickly. For example, Wenglinsky (1998), in a large-scale study, found that students who used computers in constructivist ways to learn mathematics (e.g., using simulations and spreadsheets) scored significantly higher on math achievement assessments than students whose only exposure was to computer-based drill-and-practice programs. These simulations and spreadsheets enabled students to relate information to real life and solve problems logically.

Despite studies documenting the effectiveness of technology to support student learning, barriers to technology integration have been identified. For example, the issue of preparedness of teachers to respond to the influx of technology resources, and of schools to keep up with the mechanical functioning and maintenance of equipment, was one major barrier. Further, many teachers had not been prepared to utilize technology in their teacher preparation programs. The U.S. Office of Technology Assessment (1995) found that schools devoted no more than 15% of their technology budgets to professional development. More recently, Carvin (2000) suggested that professional development should be closer to 30%, but unfortunately was as low as 3% in some districts. Without time and monetary resources devoted to increasing staff expertise in technology use, effective integration was a struggle. Still, optimism regarding the power of technology remained.

Barriers to technology integration have been identified that span practical issues of time for professional development (Jones, 1998), lack of systemic planning (Cradler, n.d.), and

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lack of support for networks and hardware at individual school sites (Fulton & Sibley, 2003). However, although much of what is written regarding technology integration focuses on barriers to its use, others have theorized conditions under which integration might best occur (Chang et al., 1998; Gooler, Kautzer, & Knuth, 2000; WestEd, 2002; White, Ringstad, & Kelly, 2002), namely, providing ample professional development for teachers, making certain that technology supports the curriculum, and providing a solid infrastructure to support the technology itself. Still other researchers have examined particular technologies with students in specific content areas, measuring the effect of technology on achievement (Butzin, 2001; Zhang, 2000; Doty, Popplewell, & Byers, 2001).

So although instructional technology has been a routine part of the educational landscape for several decades, the integration of technology in classrooms still lags behind expectations for its use (Cuban, 2001; Jones, 1998; Rogers, 2000), and especially for traditionally underserved populations (Solomon, Allen, & Resta, 2003). For example, in 1999, in schools where the free lunch rate was 70% or higher, only 39% of classrooms had Internet access, while schools where free lunch was less than 11% reported that 74% of classrooms had Internet access (Solomon et al., 2003). Even though Hativa (1988), in a meta-analysis of the use of computer-based drill-and-practice in arithmetic, determined that it was widening the gap between high- and low-achieving students, teachers continue to use technology as a drill-and-practice remediation tool, particularly with students of color. Similarly, researchers have noted that teachers in poorer schools utilize technology to reinforce basic skills, rather than to support higher-order thinking (CEO Forum, 2001).

Fewer research studies, however, have paid close attention to contextual variables and factors that might affect the nature and degree of technology integration in schools, particularly urban schools. One longitudinal research effort examining systemic reform in Union City, New Jersey, determined that in the absence of school reform, technology would not have a sustained positive effect on learning (Honey, Culp, & Carrigg, 2000). In particular, they found that variables such as instructional leadership, extensive professional development, a whole-language approach to learning, establishment of libraries, de-emphasis on remediation, and emphasis on fostering student creativity were necessary to maximize the effect of technology on student learning.

The purpose of this study was to describe the ways in which three urban elementary schools, in partnership with a local, publicly funded multipurpose university, used a similar array of material and human resources to improve their integration of technology. This paper is framed from the perspective of how new technology resources are absorbed into an existing, normative ecosystem, namely, the school culture (Bronfenbrenner, 1994; Sarason, 1982) in each of these buildings. Our interest in framing the

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Uses and Effects of Mobile Computing Devices in K–8 Classrooms

Karen Swan | Kent State University
Mark van 't Hooft | Kent State University
Annette Kratcoski | Kent State University
Darlene Unger | Virginia Commonwealth University

This preliminary study employed mixed methodologies to explore students' use of mobile computing devices and its effects on their motivation to learn, engagement in learning activities, and support for learning processes. Data collected from students in four elementary and two seventh grade science classes in Northeast Ohio included usage logs, student work samples, student and teacher interviews, and classroom observations. Findings highlight the personalization of learning afforded by such devices both in terms of individuals and individual classroom cultures, as well as their usefulness in extending learning beyond the classroom. They also suggest that increased motivation due to mobile device use leads to increases in the quality and quantity of student work.

Background

More than a decade ago, Mark Weiser (1991) wrote that we live in a society in which technology is so pervasive that we do not notice it anymore when used for everyday tasks such as information retrieval, communication, and entertainment. Defining this environment as ubiquitous computing, he described it more as a state of mind, as "a new way of thinking about computers in the world … [that] allows the computers themselves to vanish into the background … [and] become indistinguishable from everyday life" (p. 94). As a result, the current generation of K–12 students is growing up more technologically literate than children their age were a decade ago, with access to an increasing number of devices and services such as video game consoles, mobile gaming devices, cell phones, the Internet, and instant messaging. Interestingly enough, even though many students know and use these technologies as integral parts of their lives, they learned to do so mostly outside of school (U.S. Department of Education, 2004), and teachers are struggling to integrate technology into their curriculum.

However, there are signs that the idea of ubiquitous computing is starting to get a foothold in K–12 settings, as a vision of classrooms filled with many computing devices designed for differing purposes and to be used as needed in the same ways as pencils and paper and books are used now. This vision is accompanied by a need for systematic research to investigate its effect, which is especially important given the argument that technology can play a more significant role in education and everyday life if it becomes more human-centered and less visible. For learning, the implication is that the smaller and less disruptive the device, the more of a chance it stands of becoming a lifelong-learning tool for anyone, anywhere, anytime (Inkpen, 2001; Sharples, 2000).

Given this theoretical framework and their relatively low cost, handheld computers are becoming an increasingly compelling choice of technology for K–12 classrooms because they enable a transition from the occasional, supplemental use of classroom computers and school computer labs to the frequent, integral use of portable computational devices (Soloway et al., 2001; Tinker & Krajcik, 2001). Early evaluations indicate that teachers and students respond favorably to handheld devices, and suggest handheld computers have the potential to affect student learning positively across curricular topics and instructional activities. Teachers, for example, have indicated that students are more motivated, spend more time using technology, collaborate and communicate more, and benefit from having a portable and readily accessible tool (Vahey & Crawford, 2002). Students, in turn, have found handhelds easy to use, fun, and a useful tool for learning (van 't Hooft, Diaz, & Swan, 2004).

Perhaps more important, some researchers argue that classrooms with handheld computers differ fundamentally from more traditional desktop computing environments

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in that users interacting with handheld computers can also interact with each other and other computing devices at the same time (Cole & Stanton, 2003; Danesh, Inkpen, Lau, Shu, & Booth, 2001; Mandryk, Inkpen, Bilezkjian, Klemmer, & Landay, 2001). Handheld computers thus have the potential to support both personalized and collaborative learning. Roschelle and Pea (2002), for example, highlight three ways handheld devices have been used to increase learning collaboratively—classroom response systems, participatory simulations, and collaborative data gathering—and suggest there are many more such uses (Danesh et al., 2001; Mandryk et al., 2001; Roschelle, 2003).

Finally, because of their small size, handheld computing devices no longer constrain users in the way desktop computers or even laptops do. As such, handheld computers support learning outside the classroom, twenty-four hours a day, seven days a week. They thus have the potential to support lifelong-learning anywhere, anytime (Bannasch, 1999; Inkpen, 2001; Sharples, 2000; Soloway et al., 2001; Staudt & Hsi, 1999; Tinker, 1997).

However, the limited size of most handhelds may be a disadvantage as well as an advantage (van 't Hooft et al., 2004). Screen size is an issue for some, but text input on handheld computers is a more pressing one, especially at the elementary level. Unless students attach an external keyboard, which costs more money, takes up space, and affects mobility, text input is limited to the onscreen keyboard or text recognition software (Vahey & Crawford, 2002). Primary teachers, in particular, believe that text recognition software can confuse students who are learning to write (van 't Hooft et al., 2004). In contrast, mobile computing devices such as the ones used in this study (AlphaSmart's Dana) may be the best of both worlds. On one hand, they feature a handheld-specific operating system, integrated wireless capabilities, and a full-size keyboard, and therefore function like handheld computers without the text input issues. On the other hand, they are relatively small and lightweight, and are cheaper and easier to use than full-blown laptop computers. The devices used in the study were donated by AlphaSmart as part of a research grant, and are referred to as "mobile computing devices" throughout the remainder of this article.

Research on the effects of mobile computers on teaching and learning is still relatively scarce (van 't Hooft et al., 2004). This preliminary study was designed to begin exploring the use of mobile computing devices and its effects on student learning. The following questions were addressed:

1. How do students use mobile computing devices?
2. Does the use of mobile computing devices affect students' motivation to learn and engagement in learning?
3. Does students' use of mobile computing devices support learning processes?

Methodology

SUBJECTS AND SETTINGS

Data were collected from subjects at two sites during the 2003–2004 school year. The first site was a technology-rich laboratory classroom at a state university in northeast Ohio where local teachers (who are nominated by their administrators and subjected to a selection process) bring their classes to complete regular units of study in a ubiquitous computing environment. Classes spend half a day every day for six weeks in the classroom, with access to desktops, wireless laptops, and handheld computers (1:1), a document camera, a presentation system, scanners, printers, digital cameras, teleconferencing equipment, video and audio recorders, VCRs, video editing equipment, CD and DVD burners, digital microscopes, scientific probes, wireless writing pads, and a wide variety of software to support teaching and learning.

Classes and subjects involved at the first site included one sixth grade class (n = 28), two fourth grade classes (n = 41), and one third grade class (n = 16). The sixth grade class's work centered on a biography project; one of the fourth grade classes studied plants and the environment; the other fourth grade and third grade classes, both from the same district, worked on identical projects organized around a study of flight. All students were given mobile computing devices to use and take home for the six-week period their classes spent in the laboratory classroom. In this part of the study, we were especially interested in the ways in which the use of mobile computing devices might support student development of conceptual understanding. Thus, representative students (high achieving, middle, low, special needs) in each class were closely followed. Representative students were identified by their teachers.

The second site was a suburban middle school in northeast Ohio whose student population of approximately 380 is drawn from two elementary schools, one attended by children from upper middle class, white-collar families and the other attended by middle class, blue-collar families. The school's students are primarily (about 98%) Caucasian. At the time of the study, about 20% of students qualified for free or reduced lunch. Students (n = 50) in two (out of five) seventh grade science classes, all taught by the same teacher, were given mobile computing devices to use in science class and to take with them for a little more than half the school year. In this part of the study, we focused on the support mobile computing devices might provide in science learning, both in terms of motivation as well as conceptual understanding.

DATA SOURCES AND ANALYSES

Data collected from all six classes included lesson plans, usage data, work samples, student and teacher interviews, and classroom observations, some of which were