Teacher Technology Change: How Knowledge, Confidence, Beliefs, and Culture Intersect

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Abstract

Despite increases in computer access and technology training, technology is not being used to support the kinds of instruction believed to be most powerful. In this paper, we examine technology integration through the lens of the teacher as an agent of change: What are the necessary characteristics, or qualities, that enable teachers to leverage technology resources as meaningful pedagogical tools? To answer this question, we discuss the literature related to four variables of teacher change: knowledge, self-efficacy, pedagogical beliefs, and subject and school culture. Specifically, we propose that teachers' mindsets must change to include the idea that "teaching is not effective without the appropriate use of information and communication technologies (ICT) resources to facilitate student learning." Implications are discussed in terms of both teacher education and professional development programs. (Keywords: teacher change, teacher knowledge, teacher beliefs, technology integration)

Professionals of the 21st century think and act differently than those of previous centuries, due at least in part to the radically different tools they use to perform their jobs. Police officers instantly search online databases to determine if the driver of a speeding car has a valid driver's license or outstanding tickets or warrants for his/her arrest. Mechanics use computerized diagnostics to identify which part of your engine or vehicle needs to be serviced after you notice that the "check engine" light is on. Doctors use high-frequency sound waves to scan a woman's abdomen to create 2-D, 3-D, or even 4-D images of an unborn child, nearly eliminating the guesswork involved in determining the age, sex, and health status of the fetus. Most of us today would not consider the uses of these tools to be particularly unusual or innovative; rather, they are simply the expected "tools of the trade." Furthermore, if our mechanics or doctors did not use these tools, we would deem them out of date and take our business elsewhere.

Not surprisingly, most citizens expect their medical and law enforcement professionals, and even their mechanics, to be up to date regarding the latest technologies that enable them to perform their jobs efficiently and effectively.

However, this expectation is rarely applied to classroom teachers. Teachers of the 21st century use roughly the same tools as those who came before them (Cuban, 2001). Furthermore, whereas the benefits of technology in other professions are determined by comparing the results to the intended outcomes (e.g., Did the police officer arrest the speeding driver who had a suspended license? Did the mechanic accurately identify the problem and get the car running again? Did the doctor identify potential health concerns for the baby?), teachers' uses of technology are rarely linked to the student learning outcomes they are designed to facilitate (Lawless & Pellegrino, 2007). It is time to shift our mindsets away from the notion that technology provides a *supplemental* teaching tool and assume, as with other professions, that technology is *essential* to successful performance outcomes (i.e., student learning). To put it simply, effective teaching requires effective technology use.

Recent research, resulting from both large- and small-scale efforts (Bauer & Kenton, 2005; Project Tomorrow, 2008), suggests that we have yet not achieved high levels of effective technology use, either in the United States or internationally (Kozma, 2003; Mueller, Wood, Willoughby, Ross, & Specht, 2008; Smeets, 2005; Tondeur, van Braak, & Valcke, 2007a). Furthermore, if and when technology is used, it typically is not used to support the kinds of instruction (e.g., student-centered) believed to be most powerful for facilitating student learning (Cuban, Kirkpatrick, & Peck; 2001; International Society for Technology in Education [ISTE], 2008; Partnership for 21st Century Learning, 2007).

No doubt, teachers have increased their personal and professional uses of computers (Project Tomorrow, 2008; van Braak, Tondeur, & Valcke, 2004). In response to the Teachers Talk Tech survey (CDW-G, 2006), 88% of the teachers reported using technology for administrative tasks, whereas 86% reported using technology for communication tasks. Similarly, 93% of the teachers who responded to the Speak Up 2007 survey (n = 23,756/25,544) reported using technology to communicate with colleagues or parents (Project Tomorrow, 2008).

Alongside these increases in teachers' professional uses are increases in the reported instructional uses of computers in the classroom (National Education Association, 2008; Project Tomorrow, 2008). Unfortunately, when we look closer at these data, reported uses still tend to be "low-level" (Maddux & Johnson, 2006; Russell, Bebell, O'Dwyer, & O'Connor, 2003)—that is, those that support traditional, teacher-directed instruction (e.g., using PowerPoint to present a lesson, searching the Web for information resources) or that focus on the development of students' technical skills (Tondeur, van Braak, & Valcke, 2007b). Based on the results of the Speak Up 2007 national survey (Project Tomorrow, 2008), 51% of the responding teachers (n = 13,027 / 25,544) reported that their primary uses of technology to "facilitate student learning" comprised (a) asking students to complete homework

assignments using the computer (e.g., writing reports, finding information on the Internet) and (b) assigning practice work at the computer (e.g., using drill-and-practice software). These results are verified, to some extent, by the large percentage of students (grades 6–12) taking the same survey who reported using technology to (a) write assignments (74%), (b) conduct online research (72%), and (c) check assignments or grades online (58%).

Technology Integration for 21st-Century Learners

As with other professionals, we expect teachers to use technology in ways that extend and increase their effectiveness. It is no longer appropriate to suggest that teachers' low-level uses of technology are adequate to meet the needs of the 21st-century learner. Using technology simply to support lecture-based instruction falls far short of recommended best practice (Lawless & Pellegrino, 2007; Partnership for 21st Century Skills, 2007; Zemelman, Daniels, & Hyde, 2005). Although survey data may suggest that the "teaching process is fundamentally changing as professional development is taking teachers from learning how computers work to using technology to *change* how they teach" (CDW-G, 2006, para. 3, emphasis added), current data from classroom observations do not support this view (Andrew, 2007; Bauer & Kenton, 2005; Schaumburg, cited in Schulz-Zander, Pfeifer, & Voss, 2008). Even among teachers who claim to have student-centered, constructivist practices, technology uses are described as not being particularly powerful or innovative (Cuban, Kirkpatrick, & Peck; 2001; Hermans, Tondeur, van Braak, & Valcke, 2008).

To achieve the kinds of technology uses required for 21st-century teaching and learning (Lai, 2008; Law, 2008; Thomas & Knezek, 2008), we need to help teachers understand how to use technology to facilitate meaningful learning, defined as that which enables students to construct deep and connected knowledge, which can be applied to real situations. Although "technology can make it quicker or easier to teach the same things in routine ways," it also makes it possible to "adopt new and arguably better approaches to instruction and/or change the content or context of learning, instruction, and assessment" (Lawless & Pellegrino, 2007, p. 581). These latter uses are precisely the ones that the majority of today's teachers find most challenging, perhaps because they require the most amount of change.

With the No Child Left Behind Act (U. S. DOE, 2001) providing impetus, states are now placing strong emphasis on recruiting and retaining high-quality teachers. In addition to possessing both content and pedagogical knowledge, recent definitions of high-quality teachers include being able to support differentiated instruction and data-based decision making, efforts that benefit immensely from the use of new technology tools (Means, Padilla, DeBarger, & Bakia, 2009; Office of Educational Technology, 2004; Patrick, 2008). According to the U. S. DOE (2003), "Technology is now considered by most educators and parents to be an integral part of providing a high-quality education" (p. 3).

Addressing Teacher Change

Issues of teacher change are central to any discussion of technology integration. In general, when teachers are asked to use technology to facilitate learning, some degree of change is required along any or all of the following dimensions: (a) beliefs, attitudes, or pedagogical ideologies; (b) content knowledge; (c) pedagogical knowledge of instructional practices, strategies, methods, or approaches; and (d) novel or altered instructional resources, technology, or materials (Fullan & Stiegelbauer, 1991). When thinking about technology as an innovation, Fisher (2006) cautioned against viewing technology as an agent of change. Rather, he argued that teachers must assume this role. Harris (cited in Brinkerhoff, 2006) noted that "using technology as a 'Trojan horse' for educational reform has succeeded in only a minority of K–12 contexts" (pp. 39–40). In this paper we follow Fisher's lead to take a closer look at change through the lens of the individual as an agent of change: What are the necessary characteristics, or qualities, of teachers that enable them to leverage information and communication technologies (ICT) resources as meaningful pedagogical tools? Following this we ask an essential corollary question: How can schools support teachers' efforts?

In general, teachers are hesitant to adopt curricular and/or instructional innovations (Ponticell, 2003). This is especially true of technology innovations because unlike curricular changes (e.g., Everyday Math), which occur only periodically, technology tools and resources are constantly changing (Straub, 2009). And although teachers might believe that technology helps them accomplish professional and/or personal tasks more efficiently, they are reluctant to incorporate the same tools into the classroom for a variety of reasons including the lack of relevant knowledge (Lawless & Pellegrino, 2007), low self-efficacy (Mueller et al., 2008), and existing belief systems (Ertmer, 2005; Hew & Brush, 2007; Subramaniam, 2007). Furthermore, the context in which teachers work often constrains or limits individual efforts (Roehrig, Kruse, & Kern, 2007; Somekh, 2008). We discuss each of these variables in more detail.

Knowledge as a Key Variable

As described by Borko and Putnam (1995), teacher knowledge has a significant impact on teachers' decisions. Thus, "… to help teachers change their practice, we must help them to expand and elaborate their knowledge systems" (Borko & Putnam, 1995, p. 37). For more than 20 years, teacher knowledge has been conceptualized using the framework proposed by Shulman (1986, 1987). According to Shulman (1986), teacher knowledge includes knowledge of the subject (content knowledge, CK), knowledge of teaching methods and classroom management strategies (pedagogical knowledge, PK), and knowledge of how to teach specific content to specific learners in specific contexts (pedagogical content knowledge, PCK). In addition to these three commonly discussed categories, Shulman (1987)

described four other categories that, together with the first three, comprise the knowledge base of teaching: knowledge of the materials for instruction, including visual materials and media (curricular knowledge); knowledge of the characteristics of the learners, including their subject-related preconceptions (learner knowledge); knowledge of educational contexts, including classrooms, schools, district, and beyond (context knowledge); and knowledge of educational goals and beliefs.

Although media are mentioned in Shulman's definition of curricular knowledge (1986), technology skills and knowledge receive only cursory mention at best. One of the unintended consequences of this definition is that technology has yet to be integrated into the definition of good teaching (Fajet, Bello, Leftwich, Mesler, & Shaver, 2005). In other words, teachers can think they are doing a great job, even if they or their students never use technology. Although this may have been true 20 years ago, this is no longer the case. We need to broaden our conception of good teaching to include the idea that teaching is effective only when combined with relevant ICT tools and resources.

To use technology to facilitate student learning, teachers need additional knowledge and skills that build on, and intersect with, those that Shulman (1986) described. This additional knowledge has been conceptualized in a variety of ways including (technological pedagogical content knowledge, TPCK; AACTE, 2008; Pierson, 2001), pedagogical technology integration content knowledge (PTICK; Brantley-Dias, Kinuthia, Shoffner, DeCastro, & Rigole, 2007); and ICT-TPCK (a strand of TPCK that specifically emphasizes relevant knowledge of information and communication technologies; Angeli & Valanides, 2009). According to Angeli and Valanides, these models are founded on the common principle that effective technology integration depends on a consideration of the interactions among technology, content, and pedagogy. That is, technology integration requires that pre- and inservice teachers understand: (a) the technology tools themselves, combined with (b) the specific affordances of each tool that, when used to teach content, enable difficult concepts to be learned more readily, thus resulting in the achievement of meaningful student outcomes (Angeli & Valanies).

First, teachers need knowledge of the technology itself. Lawless and Pellegrino assert that "technological literacy has fast become one of the basic skills of teaching" (2007, p. 580). If teachers are going to prepare their students to be technologically capable, they need to have, at the very least, basic technology skills. This expectation is reflected in the NETS-T [teacher] standards (ISTE, 2008), first published in 1998. Since that time, the NETS-T have been adopted by the National Council for the Accreditation of Teacher Education (NCATE), as well as the vast majority of states (ISTE, 2003). Although most teachers graduating today are likely to be "digital natives" (comfortable using a variety of technology tools), the majority of inservice teachers is, or has been, expected to gain these skills through other means

(e.g., additional courses, workshops, peer collaborations, etc.). And, based on the survey data reported earlier (CDW-G, 2006; Project Tomorrow, 2008; Voogt, 2008), a large number of teachers have complied.

However, *knowing how* to use technology hardware (e.g., digital camera, science probe) and software (e.g., presentation tool, social networking site) is not enough to enable teachers to use the technology effectively in the classroom. In fact, if this were true, there would be little, if any, gap between teachers' personal and instructional uses of technology. But knowing how to use the tools is only the foundation. Teaching with technology requires teachers to expand their knowledge of pedagogical practices across multiple aspects of the planning, implementation, and evaluation processes. For example, when using technology as an instructional tool teachers must know how to: develop plans for teaching software to students, select appropriate computer applications to meet the instructional needs of the curriculum and the learning needs of their students, and manage computer hardware and software (Coppola, 2004). According to Hew and Brush (2007), lack of these technology-related management skills can inhibit technology integration.

To use technology to support meaningful student learning, teachers need additional knowledge of the content they are required to teach, the pedagogical methods that facilitate student learning, and the specific ways in which technology can support those methods. For example, as teachers involve their students in more interdisciplinary work their content knowledge needs to grow. Pedagogical knowledge also needs to expand to include ideas about how to "develop students' abilities to work collaboratively or to take control of their own learning in an ICT-rich environment" (Webb & Cox, 2003, p. 277). Finally, teachers need to understand the relationships between the affordances of a range of ICT resources and the skills, concepts, and processes of a content domain (PCK). Based on their knowledge of both their learners and the subject, teachers need to be able to select the most appropriate ICT resources to enable their students to meet the required learning goals.

According to Cennamo, Ross, and Ertmer (2010), to achieve technology integration that targets student learning, teachers need knowledge that enables them to:

- Identify which technologies are needed to support specific curricular goals
- Specify how the tools will be used to help students meet and demonstrate those goals
- Enable students to use appropriate technologies in all phases of the learning process including exploration, analysis, and production
- Select and use appropriate technologies to address needs, solve problems, and resolve issues related to their own professional practice and growth. (p. 10)

Unfortunately, learning about technology is equivalent to asking teachers to hit a moving target. Teachers will never have "complete" knowledge about

the tools available, as they are always in a state of flux. This often results, then, in teachers being perpetual novices in the process of technology integration (Mueller et al., 2008), which suggests the need for teachers to have strong self-efficacy for teaching with technology. We discuss this variable next.

Self-Efficacy as a Key Variable

Although knowledge of technology is necessary, it is not enough if teachers do not also feel confident using that knowledge to facilitate student learning. This seems to be particularly true for novice teachers. Piper (2003) reported a significant influence of self-efficacy on novice teachers' classroom uses of technology based on her survey of 160 elementary and secondary teachers. In fact, evidence suggests that self-efficacy may be *more important* than skills and knowledge among teachers who implement technology in their classrooms. Results from a small-scale study by Bauer and Kenton (2005) noted that a greater number of technology-using teachers rated themselves as being highly confident (n=14) for using computer technology, compared to being highly skilled (n=9). In a survey of 764 teachers, Wozney, Venkatesh, and Abrami (2006) found that one of the two greatest predictors of teachers' technology use was their confidence that they could achieve instructional goals using technology. This suggests that time and effort should be devoted to increasing teachers' confidence for using technology, not just to accomplish administrative and communicative tasks, but to achieve student learning objectives.

How do we help teachers gain this confidence? The most powerful strategy appears to be helping teachers gain personal experiences that are successful (personal mastery), although other methods can also increase self-efficacy (e.g., vicarious experiences, persuasion). As Mueller et al. (2008) noted:

> Although computer related variables, in general, continue to impact on teachers' ability to integrate technology, it is positive experiences with computers in the classroom context that build a teacher's belief in computer technology and confidence in its potential as an instructional tool. (p. 1533)

Furthermore, when teachers witness how technology facilitates student success, confidence also increases (Ottenbreit-Leftwich, 2007).

A number of suggestions for building computer or technology self-efficacy are offered in the literature:

- Giving teachers time to play with the technology (Somekh, 2008)
- Focusing new uses on teachers' immediate needs (Kanaya, Light, & Culp, 2005; Zhao & Cziko, 2001)
- Starting with small successful experiences (Ottenbreit-Leftwich, 2007)

- Working with knowledgeable peers (Ertmer, Ottenbreit-Leftwich, & York, 2006)
- Providing access to suitable models (Albion, 1999; Ertmer, 2005)
- Participating in a professional learning community (Putnam & Borko, 2000)
- Situating professional development programs within the context of teachers' ongoing work (Cole, Simkins, & Penul, 2002; Snoeyink & Ertmer, 2001/2002).

In addition, because "innovation and adaptation are costly in terms of the time needed to develop and establish new practices" (Hennessey, Ruthven, & Brindley, 2005, p. 162), we need to assure that teachers are given adequate time to make these desired changes.

Still, a sound knowledge base and strong self-efficacy for teaching with technology do not readily manifest themselves as meaningful technology uses (Tillema, 1995). The results of the study by Wozney et al. (2006) mentioned earlier noted the strong influence of both confidence and perceived value on technology classroom use, suggesting that self-efficacy by itself may not be enough. In addition, teachers need to value technology as an instructional tool. Given this, it is important to investigate how teacher beliefs underlie and support meaningful technology uses.

Pedagogical Beliefs as a Key Variable

Rokeach (1972) defined a belief as any proposition that begins with the phrase "I believe that." Beliefs that have multiple links to other beliefs are considered to be "core" or central beliefs: "The more a given belief is functionally connected or in communication with other beliefs, the more implications and consequences it has for other beliefs" (Rokeach, 1972, p. 5). Thus, core beliefs are the most difficult to change, as their connections to other beliefs need to be addressed as well (Richardson, 1996).

Teacher belief systems comprise a myriad of interacting, intersecting, and overlapping beliefs (Pajares, 1992). According to Hermans et al. (2008), "Belief systems consist of an eclectic mix of rules of thumb, generalizations, opinions, values, and expectations grouped in a more or less structured way" (p. 1500). Many have suggested that these belief systems influence how teachers use technology in the classroom (Angers & Machtmes, 2005; Hermans et al., 2008; Windschitl & Sahl, 2002). In a study by Haney, Lumpe, Czerniak, and Egan (2002), teacher beliefs were found to predict subsequent classroom action for five of the six teachers observed. In general, teachers with more traditional beliefs will implement more traditional or "low-level" technology uses, whereas teachers with more constructivist beliefs will implement more student-centered or "high-level" technology uses (Judson, 2006; Roehrig et al., 2007). Hermans and his colleagues noted "traditional beliefs had a negative impact on integrated use of computers" (p. 1499).

Longitudinal studies investigating teachers' adoption of technology have described a "pedagogical evolution" (Hennessey et al., 2005, p. 186) as teachers incorporate more technology into their practices. The authors described a "gradual but perceptible shift in subject practice and thinking" (p. 186). Other researchers have reported similar findings (Hooper & Reiber, 1995; Levin & Wadmnay, 2005; Mills & Tischner, 2003; Windschitl & Sahl, 2002). In a 10-year longitudinal study of the Apple Classrooms of Tomorrow (ACOT) program, teachers' observations of changes in their students prompted them to reflect on their current beliefs about teaching and learning, which then led to changes in their pedagogical beliefs (Sandholtz & Ringstaff, 1996; Sandholtz, Ringstaff, & Dwyer, 1997).

In addition to these pedagogical beliefs, there are beliefs attributed to value. Value beliefs encompass the perceived importance of particular goals and choices (Anderson & Maninger, 2007). In other words, teachers' value beliefs with regards to technology are based on whether or not they think technology can help them achieve the instructional goals they perceive to be most important (Watson, 2006). When a new pedagogical approach or tool is presented, teachers make value judgments about whether that approach or tool is relevant to their goals. The more valuable they judge an approach or tool to be, the more likely they are to use it. This is particularly true of technology (Zhao, Pugh, Sheldon, & Byers, 2002). When teachers learn how to use technology within their specific content areas and/or grade levels, they can more readily transfer that knowledge to their own classrooms (Hughes, 2005; Snoeyink & Ertmer, 2001/2002). When learning experiences are focused solely on the technology itself, with no specific connections to grade or content learning goals, teachers are unlikely to incorporate technology into their practices. Hughes (2005) noted that "the more content-specific the example, the more likely the teacher will see value and learn it" (p. 295).

Beliefs act as a lens or filter when people process new information, such as that which they obtain from textbooks, knowledgeable others, or experience (Tillema, 1995). Early events, especially if particularly unique or vivid, can color our perceptions of subsequent events (Nespor, 1987). Thus, teachers filter new information delivered through professional development programs through their belief systems before they assimilate it into existing knowledge structures. As Richardson (1996) noted: "The beliefs that practicing teachers hold about subject matter, learning, and teaching [will] influence the way they approach staff development, what they learn from it, and how they change" (p. 105). More specifically, Tillema (1995) examined how teachers' existing beliefs affected the knowledge acquisition process during a technology-training program. Results indicated that a greater correspondence between teachers' beliefs and training content led to greater learning. Others have described similar results: For teachers to incorporate new software or approaches into their existing knowledge structures, the uses first must align with current beliefs (Hughes, 2005; Kanaya et al., 2005; Zhao

& Frank, 2003). And because teachers tend to value that which enables them to meet student needs, they are more likely to integrate technology if they believe that it addresses important learning outcomes (Ottenbreit-Leftwich, 2007).

Although beliefs can influence knowledge acquisition and use of technology, context also plays a role in teachers' uses of technology. Teacher beliefs have been shown to be heavily influenced by the subject and school culture in which they participate. Windschitl and Sahl (2002) found that teachers' beliefs strongly influenced their technology, but the context of their institutions and profession shaped these beliefs:

> The ways in which those teachers eventually integrated computers into classroom instruction were powerfully mediated by their interrelated belief systems about learners in their school, about what constituted "good teaching" in the context of the institutional culture, and about the role of technology in students' lives. (p. 575)

Culture as a Key Variable

For many teachers, possessing the relevant knowledge, confidence, and beliefs is enough to empower them to integrate technology into their classrooms in meaningful ways. We probably all know teachers who have managed to be successful users, despite facing multiple barriers, including the lack of support (Ertmer, Gopalakrisnan, & Ross, 2001). Yet, for the vast majority of teachers, this is still not enough, as research indicates that innovative teachers are easily overpowered by pressures to conform (Ponticell, 2003; Roehrig et al., 2007). "Teachers are not 'free agents' and their use of ICT for teaching and learning depends on the interlocking cultural, social, and organizational contexts in which they live and work" (Somekh, 2008, p. 450). And, unfortunately, for most, the culture to which they must conform has not adopted a definition of effective teaching that includes the notion of technology as an important tool for facilitating student learning.

Maintaining membership in a group is important to people in general and may be even more important to teachers, given the particularly strong cultures that exist within schools (Ponticell, 2003; Roehrig et al., 2007; Somekh, 2008). Zhao and Frank (2003) noted that a technology innovation was less likely to be adopted if it deviated too greatly from the existing values, beliefs, and practices of the teachers and administrators in the school. Conversely, changes in beliefs about technology use occurred more readily among teachers who were socialized by their peers to think differently about computer use.

Brodie (2004) described this phenomenon of "culture pressure" using the concept of a meme, which he defined as an "internal representation of knowledge that results in outward effects on the world" (p. 28). Simply put, a meme is a product of a culture that gets transmitted by repetition.

> When people get immersed in a culture with strong memes, it tends to be a sink-or-swim proposition. Either you change your mind, succumbing to peer pressure and adopting the new memes as your own, or you struggle with the extremely uncomfortable feeling of being surrounded by people who think you're crazy or inadequate. The fact that you probably think the same about them is little consolation. (Brodie, 2004, p. 48)

The pressure to belong doesn't disappear after our adolescent years, but reappears in the form of norms, values, and shared beliefs among individuals in work and social contexts. Each school, and even each team of teachers within a school (discipline based or grade level based), has a set of norms that guides behaviors and instructional practices. These norms address everything from which values and goals are promoted, to which instructional methods are preferred, to which tools or resources are acceptable to use. Given this, it's not surprising that "teachers are reluctant to adopt a technology that seems incompatible with the norms of a subject culture" (Hennessey et al., 2005, p. 161).

One of the difficulties associated with introducing technology into the classroom is that it "consistently destabilizes the established routines of classroom life including norms of time and space" (Somekh, 2008, p. 452). Furthermore, experienced teachers who don't see the value of integrating technology into their classrooms can negatively impact the use of instructional technologies by newer teachers (Abbott & Faris, 2000; Hazzan, 2003). For example, Hazzan examined novice high school mathematics teachers' attitudes toward integrating technology into their instruction. Results revealed how perceptions of a negative undercurrent from veteran teachers toward such practices discouraged novices from using technology in their lessons.

Of course, culture or peer pressure can have positive results as well. For example, peer pressure can provide the motivation we need to try things we otherwise would not, especially if we are also able to observe positive results (i.e., student learning) ensuing from our efforts (Becker, 1994). Somekh (2008) described three schools (from three different countries) that enabled teachers to adopt technology in pedagogically meaningful ways. According to the author, school-wide innovation occurred in situations in which "the principal's vision and motivation were of central importance" (p. 457) and the innovation led to a "change in the nature of teacher–teacher relationships, based on collaboration and mutual support" (pp. 457–458). Additionally, all three schools were noted as having these characteristics:

1. They were well-equipped with ICT.
2. Their focus was on changing the process of learning using ICT.
3. Skills were acquired as part of the process of using them purposefully.
4. They provided support.
5. Teachers had opportunities to discuss problems with peers and facilitators and explore solutions over time.
6. The nature of students' learning changed along with the established epistemologies.

Table 1: Recommendations for Facilitating Teacher Change

	Preservice Teacher Education	Inservice Professional Development
Knowledge and Skills	Hands-on experiences with technology "tools of the trade" (e.g., productivity and instructional tools), including those used for differentiated instruction, data-based decision making, etc. Observations (video, field experiences, methods faculty) of "best practices" technology use Readings and discussions of articles that link best practices technology use to student learning outcomes Reflection on current and expanded definitions of good teaching; discussions of technology's role in current and revised definitions Opportunities to practice using technology to facilitate learning (in K–12 classrooms, in college classroom in form of micro-teaching)	Exposure to and practice with technology uses that directly relate to existing PCK to encourage adoption and incorporation into current practices Support of small steps toward teacher change Discussions with other teachers related to how technology tools can be used in specific ways to increase student learning outcomes Situated professional development efforts that enable teachers to learn about technology tools within their own schools/classrooms Intense professional development experiences, followed by continued support and community discussions Opportunities to practice managing technology in the classroom by providing additional help (teacher aides, parents, advanced students, etc.)
Self-Efficacy	Multiple opportunities to use technology as an instructional tool • College classroom (micro-teaching, simulated lessons) • Field experiences (practica, student teaching) Access to wide variety of models and examples	Opportunities to share success stories related to using technology to facilitate student learning, at grade-level or discipline-based teacher meetings Opportunities to witness other teachers using technology in their classrooms Encouragement/expectation of small changes with technology over extended time period Implementation of a culture that encourages and supports experimentation
Pedagogical Beliefs	Reflection on and discussion of current beliefs Evidence of successful student learning stemming from approaches based on different beliefs Interaction with others who support/use new approaches	Support staff available to ensure initial uses with technology are successful experiences Professional development initiatives that align with teacher beliefs (identify teachers' existing beliefs to help design PD programs) Observations of other teachers' successful technology practices that are based on new ideas about teaching and learning
School/ Subject Culture	Pervasive use of effective technology tools throughout teacher education program, including content and methods courses and field experiences Discussion of pressures likely to occur in school contexts and delineation of strategies to address (formation of learning communities; alignment with technology-using mentors) Partnerships with local K–12 schools and teachers to incorporate technology into classroom instruction Discussion of future roles as professionals • Teachers as scholars • Teachers as researchers • Teachers as lifelong learners	Development of shared vision for technology use and definition of "good" teaching Expectations that professional development plans include technology Regular meetings to monitor progress in technology professional development Participation in K–12 partnerships designed to integrate technology into lessons for purposes of facilitating student learning Professional development designed to nurture teachers' roles as professionals • Teacher as scholars • Teachers as researchers • Teachers as lifelong learners

If a school doesn't have these characteristics, it's still possible that the subject culture to which a teacher belongs can initiate and support meaningful technology uses, particularly at the middle and high school levels, where teachers tend to work on grade-level or discipline-based teams. In a recent study, Howard (2008) found that in a hierarchical culture (such as what exists in schools), technology use was considered low risk as long as it was used in ways that were sanctioned by a person in authority. Although in most elementary or primary schools this authority resides with the principal, in middle and high schools this role is often shared with the leaders of discipline- or grade-level teams. This underscores the importance of facilitating the development of technology leadership skills among administrators (Ertmer, Bai, Dong, Khalil, Park, & Wang, 2002).

The underlying message here is that teachers' knowledge and beliefs appear to interact with the existing culture to create action. Ford (1992) proposed the concept of personal agency beliefs to explain how self-efficacy and context beliefs combine to create agency, or action. According to Ford, personal agency beliefs comprise "anticipatory evaluations" about whether one can achieve a goal, given (a) his/her personal capabilities and (b) the responsiveness of the environment (p. 45). If the individual anticipates that he/she will not be able to achieve the desired outcomes due to constraints imposed by personal or contextual factors, he/she will likely halt the specific action or not even undertake it at all.

The Intersection of Knowledge, Beliefs, and Culture: Implications for Practice

Literature related to teacher change in general, and technology integration more specifically, has focused extensively on the variables discussed here: knowledge, self-efficacy, pedagogical beliefs, and culture. When thinking about ways to change teachers' technology practices, we need to consider all of these factors, or we are unlikely to be successful in influencing teacher change over the long term. Helping teachers achieve the types of changes described will require a two-pronged approach that addresses these factors (a) during teacher education programs and (b) during professional development programs for practicing teachers. In this way, both sets of teachers can benefit from, and contribute to, this proposed definition of effective teaching. In the next section, we provide specific suggestions for facilitating changes in teachers' knowledge, confidence, and beliefs that have the potential to create a sustainable culture that supports technology as an integral facet of student learning. For easy reference, Table 1 provides a summary of these recommendations.

Implications for Teacher Education

Affecting knowledge change. It is generally acknowledged that preservice teachers need to have a better understanding of how to use technology to

facilitate learning (Angeli & Valanides, 2009). Although today's students may be fairly knowledgeable about a variety of ICT tools, they have little to no knowledge about how to use these tools to facilitate student learning. Furthermore, teachers need to know how to use these tools to facilitate *student-centered* instruction. "Teacher learning should prepare teachers not only for *any* kind of ICT integration, but should equip teachers for '*best practices*' in ICT integration that contribute to improving existing teaching practice to achieve the goals of school reform" (Holland cited in Law, 2008, p. 427; emphasis added).

During their teacher education programs, preservice teachers need to be challenged to adopt new definitions of learning, as well as new definitions of effective teaching, that align with recommended best practices (Tatto, 1998). As much as possible, new definitions need to include the expectation that technology as a tool, process, or method will be an integral component. Although traditional definitions of learning have focused primarily on achievement, new definitions focus on engagement, participation, and knowledge creation (Lai, 2008). Thus, preservice teachers need to know (a) how to facilitate these types of learning outcomes among their future students, and (b) how to use technology to support these goals. Furthermore, they need to know how to do this in the current climate of standards-based instruction and high-stakes testing. Thus, it is essential that we provide our future teachers with solid evidence that technology-based, student-centered instruction can have a positive impact on students' learning and their achievement on standardized tests, particularly if this continues to be the yardstick by which they are measured. (See, for example, work by Newmann, Bryk, & Nagaoka [2001] and Geier et al. [2008].) With this knowledge, then, will come new understandings, as well as new definitions, of *technology integration,* which, according to Brinkerhoff (2006), have an impact on the manner in which teachers use technology in their classrooms.

One of the most powerful strategies we can use to help our preservice teachers gain the necessary knowledge is to provide opportunities for them to observe a variety of examples and models (Albion, 2003; Ertmer et al., 2003; Zhao & Cziko, 2001). Given that new teachers are likely to have seen few instances of technology integration, examples and models can provide needed knowledge about what technology integration looks like. These examples can be modeled by teacher education faculty who teach methods courses as well as by supervising teachers during practicum or student teaching experiences.

Additionally, to help preservice teachers "own" this knowledge, we need to provide opportunities for them to practice these same or similar strategies, with real learners in real classrooms. For example, Swain (2006) noted that although preservice teachers were knowledgeable about using educational technologies, their reported teaching practices did not include technology use. Field experiences provide one way to give preservice teachers the opportunity

to test strategies, visually see the consequences of their approaches, receive feedback, and adapt their practices to better integrate technology into the K–12 classroom (Dawson & Norris, 2000; Simpson, 2006). Of course, field experiences are more effective if students have the opportunity to observe and interact with positive role models, although these may be logistically challenging to arrange (Ertmer & Albion, 2002). Alternative approaches (video cases, Web-based scenarios) can be used for meeting some of these needs.

Affecting self-efficacy belief change. One of the explanations for the gap between what teachers know and what they do relates to their confidence, or self-efficacy, for performing the task successfully. As noted earlier, the most powerful source of efficacy information is personal mastery, followed by vicarious experiences (Bandura, 1997). Both of these provide useful strategies for building confidence among preservice teachers.

Although we might expect our current preservice teachers to be more prepared to use technology than their inservice counterparts, this does not seem to be the case (Russell et al., 2003). Preservice teachers still need opportunities to develop skills using technology as an instructional tool (Russell et al.). This can be accomplished both within the college classroom (microteaching, simulated lessons) and through field experiences (practica, student teaching). The more experiences students have, the more likely they will be comfortable using technology to facilitate learning in their future classrooms. Furthermore, they need to be able to experience the entire process of facilitating a technology-based lesson, including handling the technical and management issues that commonly occur (Hew & Brush, 2007). These experiences will help students overcome their fear of making mistakes and will illustrate the importance of persistence.

As noted earlier, having access to a wide variety of models can build knowledge of what meaningful technology integration looks like. Additionally, observing successful others can build confidence in the observers who tend to believe "if he/she can do it, then I can too." The more examples our preservice teachers observe, the more likely they will gain both the knowledge and confidence they need to attempt similar uses of technology in their own classrooms (Ertmer, 2005).

Affecting pedagogical belief change. Preservice teachers enter teacher education programs with beliefs about teaching and learning that have been constructed from their own experiences as K–12 students, which, for the most part, have been fairly teacher-directed (Bruner, 1996; Windschitl & Sahl, 2002). To change these established beliefs, teacher educators need to engage preservice teachers in activities that explicate and challenge these beliefs.

Strategies suggested in the previous two sections are also relevant to affecting belief change. For example, students need opportunities to reflect on and articulate their ideas about what makes a "good" lesson and to discuss ways that technology fits within it. Students also would benefit from

observing classroom practices that are rooted in pedagogical beliefs that are different from their established beliefs, thus providing new visions of what is possible (Ertmer, 2005). Perhaps most importantly, students need to see that successful learning occurs when these beliefs are translated into instructional methods that are supported by relevant ICT tools.

Unfortunately, even if preservice teachers leave their teacher education programs with student-centered beliefs, they tend to revert to traditional practices when faced with the realities of the classroom (Roehrig et al., 2007). Yet, in the presence of appropriate induction support, Luft, Roehrig, and Patterson (cited in Roehrig et al.) reported that beginning teachers' beliefs can be stabilized. This alludes to the importance of the school culture, described next.

Affecting culture change. When considering the culture that makes an impact on the development of preservice teachers' knowledge and beliefs, we need to consider the context in which they are prepared, as well as the context in which they will teach. This suggests the need to consider the implicit messages we send students about the importance of technology during preservice teacher education programs. Is technology woven throughout our programs, or is it relegated to a single, isolated course? Do the methods faculty use technology to teach? Do methods faculty demonstrate and promote the use of technology to teach relevant subject matter? Do field placement experiences include examples of "good teaching" that include the integration of technology? If technology is going to be an integral part of preservice teachers' images of good teaching, it needs to be pervasive throughout their programs. Several PT3-funded projects stressed the importance of faculty modeling and thus included faculty development as a goal (e.g., Brush et al., 2003; Thompson, Schmidt, & Davis, 2003).

Novice teachers are particularly vulnerable to the pressures of the school culture they enter (Abbott & Faris, 2000; Hazzan, 2003). According to a recent study published by the Tennessee Department of Education (2007), teachers in high-poverty/high-minority schools actually become less effective as they gain more experience. So "while many of the beginning teachers in high-poverty/high-minority schools are among the state's most effective, many of them do not stay in these schools or they lose their effectiveness over time" (p. 7). Although there may be other reasons for teachers' loss of effectiveness as they gain more experience, there is also the very real possibility that they simply adjust their teaching styles to meet the "norms" of the existing culture, which were established by more experienced teachers.

Preservice teachers need to be aware of the pressures they will face when they begin their teaching careers and to possess effective strategies for addressing those that negate or undermine the new knowledge, confidence, and beliefs gained. Prior to graduating, teacher educators might engage their preservice teachers in discussions about ways to handle these pressures. For example, teacher educators can help preservice teachers strategize how to

obtain more resources (i.e., how to find and write grants) or how to establish professional learning networks outside of the school (i.e., using Twitter or Ning), which may help them overcome the barriers associated with an unsupportive school culture. In addition, new teachers might consider seeking out the technology leaders in the school and building positive relationships with them, working on joint projects or collaborating on classroom projects. Additionally, they might consider joining or forming a small community of teachers who are supportive of innovative teaching and technology efforts. Supportive mentors are known to help acclimate new teachers into the school culture without pressuring them to conform (Brown & Warschauer, 2006).

During their college years, preservice teachers are just beginning to develop their ideas about what it means to be professionals. Whereas the school culture they enter will ultimately impact how they enact their ideas, a strong vision of themselves as professionals, developed during their courses and field experiences, will empower them to become leaders rather than followers (Cennamo et al., 2010; Pigge & Marso, 1989). For example, as part of their courses, preservice teachers can explore ways to participate in local and global communities that are focused on creative applications of technology to improve student learning (ISTE, 2008). In addition, they can spend time developing and refining their visions of effective teaching, supported by effective technology integration. During their education courses, preservice teachers should learn how to use research findings to inform their own practice and thus become effective consumers of educational research. Finally, if taught to use action research as an ongoing method for improving practice, they might more readily join the profession as intellectuals and scholars rather than technicians (Price, 2001). As intellectuals and scholars, new teachers may be in a better position to change the culture they enter, or at the very least, not to be as greatly affected by an unsupportive culture.

To change the culture that preservice teachers enter, it also will be important to involve local K–12 schools as much as possible. By partnering with local schools, teacher educators can begin to develop communities of practice in which pre- and inservice teachers collaborate on ways to use technology to facilitate student learning (Dawson & Norris, 2000). This approach provides both preservice and inservice teachers with the opportunity to test new ideas and has been shown to increase comfort levels with technology. In addition, research has demonstrated the powerful influence that field experiences and interactions with K–12 teachers can have on the future teaching practices of preservice teachers (McNamara, 1995). Others have tried this approach with success (Staples, Pugach, & Himes, 2005).

Summary of preservice teacher change. During their teacher education programs, preservice teachers are in the process of developing their pedagogical beliefs and practices as well as their ideas about what it means to be professional teachers. Still, they do not enter the programs with blank

slates; their understandings of good teaching are based on their experiences as K–12 students. Teacher education programs can influence teacher technology change by facilitating the adoption of a new definition of good teaching, one that incorporates the use of technology to improve teaching and learning practices. This new definition of effective teaching, then, would create new requirements for graduation: Preservice teachers would not be able to graduate without providing evidence that they can use technology tools to achieve student learning outcomes. Just as new police officers must learn how to search online databases, doctors must learn how to read high-frequency sound waves, and mechanics must learn how to use computerized engine diagnostics, new teachers must learn how to use the relevant tools of their trade. That is, future teachers need to know how to use technology to facilitate student learning.

In summary, within preservice teacher education programs, the following strategies have the potential to address several of the key needs described earlier: presenting models of teaching with technology to support new definitions, providing opportunities to implement new practices and receive feedback, and providing opportunities to reflect on those practices (see Table 1). In addition, preservice teachers need to see themselves as both intellectuals and scholars who have the potential to change future practice. Finally, models and support from practitioners appear critical to facilitating preservice teacher change as well as seeing the relationship between teaching with technology and positive student outcomes.

Implications for Professional Development

Affecting knowledge change. Unlike preservice teachers, inservice teachers have existing pedagogical content knowledge (PCK) on which to build. What they typically lack, however, is specific knowledge about the technology itself, as well as how they can combine technology with their existing PCK to support students' content learning. Based on a review of the literature, Hew and Brush (2007) concluded that effective professional development for technology integration requires a focus on content that includes (a) technology knowledge and skills, (b) technology-supported pedagogical knowledge and skills (the ability to see a clear connection between the technology being used and the subject content being taught), and (c) technology-related classroom management knowledge and skills. Similarly, Kennedy (cited in Kanaya et al., 2005) noted that the most important feature of a professional development program is a strong focus on helping teachers understand how students learn specific content, and how specific instructional practices and tools can support student learning outcomes. Thus, when introducing inservice teachers to specific technology tools, it is important that professional development programs also include information about how they can use these tools in very specific ways, within specific content domains, to increase student content learning outcomes.

The interaction between technology and PCK is most easily achieved by using teachers' existing knowledge as a springboard. That is, initial professional development efforts might emphasize technology uses that directly align with teachers' existing PCK knowledge (Ertmer, 2001) and that move teachers forward in small incremental steps (Snoeyink & Ertmer, 2001/2002). One approach, described by Mishra and Koehler (2006), is that of a design-based program in which teachers develop their technology skills in the context of their curricular needs. Others (Cole et al., 2002; Ertmer et al., 2005) have incorporated mentoring or coaching components within professional development activities to target the individual needs of teachers. These are examples of what some have labeled "situated professional development" (Sugar, 2005). Situated professional development is thought to be a successful approach because it addresses teachers' specific needs within their specific environments. Therefore, teachers gain new knowledge that can be applied directly within their classrooms. However, these approaches can be challenging, especially as it takes more time to individually design technology uses and professional development that cater to the needs of individual teachers.

Inservice teachers also need to develop the knowledge and skills needed to manage a technology-rich classroom (Hew & Brush, 2007). When teachers encounter a new innovation, they have been observed to revert back to novice practices. For example, Pierson (1999) studied one experienced teacher who was a novice technology user. Although the teacher typically implemented student-centered practices in her classroom, when she taught technology-related lessons, her class became much more teacher directed. A shift from teacher-directed to student-centered practice requires extended periods of time (e.g., Sandholtz et al., 1997). Similarly, a change in teacher knowledge takes varying amounts of time, depending on each teacher's existing technology and PCK knowledge. According to Kanaya et al. (2005), the probability of implementing new technology-rich activities in the classroom is related more to the intensity of the training, as opposed to the duration. Therefore, when planning professional development programs, it is important to consider how often and for how long teachers should meet, as well as for what period of time. Research from Kanaya et al. seems to suggest it is possible to have an impact in a shorter period of time if more time is allotted up front.

Affecting self-efficacy change. Even if inservice teachers know how to use technology in their classrooms, they may still lack confidence to actually use it (Mueller et al., 2008). Schrum (1999) noted that teachers may "feel uncomfortable with technology and are fearful of looking foolish" (p. 85). Self-efficacy can be developed through positive experiences with technology. However, these experiences do not have to be personally experienced by the teacher; vicarious experiences also have the potential to develop teacher self-efficacy (Smith, 2001). In other words, teachers can develop confidence

by hearing about or observing other teachers' successful efforts. One way to accomplish this is to provide opportunities for inservice teachers to share their success stories at grade-level or discipline-based teacher meetings.

One example of an approach used to investigate effective teacher practices, and that can also facilitate experimentation with technology, is lesson study. In lesson study, small groups of teachers systematically examine specific pedagogical practices with the goal of becoming more effective teachers (Fernandez, 2002). As a group, teachers establish one goal for their classrooms and investigate the different methods that may help them reach that goal. After investigating these various methods, the teachers brainstorm to develop a "study lesson." Once the study lesson is developed, one teacher presents the collaboratively constructed lesson to his/her students while the other teachers carefully observe and take notes (Fernandez, 2002). After the public teaching, the group reconvenes to discuss their observations. Teachers then begin working on a new lesson, target a new goal or strategy, or revise the initial lesson for another teacher to pilot in his/her classroom. Teachers in Hong Kong have found this collaborative approach to professional development successful not only in improving student learning outcomes, but also in enhancing their own professional learning (Pang, 2006). "Lesson study is not just about improving a single lesson. It's about building pathways for ongoing improvement of instruction" (Lewis, Perry, & Hurd, 2004, p.18). This, then, seems particularly well suited to the development of effective technology integration skills; ideally, teachers should be constantly trying new tools and approaches to more effectively achieve student learning outcomes. Furthermore, brainstorming with fellow technology integrators has been recognized as a beneficial experience for teachers (Ottenbreit-Leftwich, 2007).

However, similar to affecting knowledge change, a change in teacher confidence can take an extended amount of time (Brinkerhoff, 2006) and is best implemented in small steps (Kanaya et al., 2005). Brinkerhoff found that after two years (90 hours) of professional development, teachers were less fearful and more confident toward using technology. When professional development is spread over a longer period of time, there is more time to experiment with new technologies in small doses. These small implementations, then, are more likely to result in success, which is key to building self-efficacy (Ringstaff & Yocam, 1994). Small steps could include introducing technology as part of a teacher's existing curriculum and/or using a familiar tool within a new lesson (Somekh, 2008). Administration can also encourage teachers' efforts by supporting experimentation. By providing opportunities to experiment, teachers do not feel pressured to avoid failures and are more likely to try new ideas in their classrooms (Brinkerhoff). Lesson study offers a specific means for promoting this type of experimentation and is one that administrators, technology coordinators, and teacher educators could easily incorporate.

Affecting pedagogical belief change. Inservice teachers are likely to have strong pedagogical beliefs built from their previous experiences in the classroom. As noted by Pajares (1992) and others (e.g., Roehrig et al., 2007), beliefs formed early in life are very resistant to change, remaining virtually unchanged over time, experiences, and education. According to Hughes (2005) and Ertmer (2005), teacher beliefs are built from personal experiences (e.g., experiences as a K–12 student, teaching experiences in their own classrooms), vicarious experiences (e.g., other teachers' experiences), and social/cultural influences (Richardson, 1996). Teachers have indicated that early successful experiences have a strong influence on the subsequent development of their technology integration abilities (Ertmer, Ottenbreit-Leftwich, & York, 2006). Others have also found that negative experiences (both personal and vicarious) can impact teachers' belief systems (Abbott & Faris, 2000; Hazzan, 2003). Experiences that are successful in changing beliefs usually occur when teachers are predisposed to the goals of the professional development program (Holt-Reynolds, 1992; Krajcik et al., 1994; Richardson, 1996). In other words, professional development initiatives that align with teacher beliefs, and that are situated within the context of their own curricular needs, are more likely lead to teacher change.

If teachers are going to adopt new beliefs about teaching and learning, they need to understand how these beliefs translate into innovative classroom practices. As suggested by Zhao and Cziko (2001), observing the successful practices of others can increase teachers' perceived need for change and increase their understandings of what new practices look like. According to Elmore, Peterson, and McCarthy (cited in Ertmer, 2005), "Teachers' practices are unlikely to change without some exposure to what teaching actually looks like when it's being done differently" (p. 34).

To truly change beliefs, teachers need to feel comfortable testing new ideas, based on these beliefs, in their classrooms. To adopt technology as an innovation, teachers need to be willing to take risks, remain flexible, and be open to change (Dexter & Greenhow, 2004; Ertmer et al., 2001; Zhao et al., 2002). Although Raths (2002) suggested that changing teacher beliefs is "hopeless," we are convinced that when teachers are able to test new approaches in their classrooms and witness positive student responses, it is possible not only to influence, but also to actually change, beliefs and practice (Borko & Putnam; Brinkerhoff, 2006; Ertmer, 2005; Ringstaff & Yocam, 1994).

Affecting culture change. In general, inservice teachers' beliefs and practices shift to align with the current school culture in which they are working (Zhao & Frank, 2003). Therefore, school leadership is a critical factor in facilitating teacher change. One of the primary roles of school leadership is to support teachers and create a shared vision for technology use. The shared vision should place emphasis on including technology as part of the definition of "good" teaching. This can be achieved by creating expectations that

professional development plans will include a technology component. In addition, engaging teachers in situated professional development, either in the form of lesson study, through the use of peer coaches, or some other means, can begin to change teachers' conversations, and eventually the expectations they have of themselves and others (Cole et al., 2005).

Giving teachers opportunities to engage in professional goal setting specifically related to technology is important to teacher change (Somekh, 2008). Reio and Lasky (2007) suggested that schools should create change-oriented environments supporting experimentation and innovation, as well as include teachers in the decision-making process. Some suggestions for professional goal setting may include meeting regularly to monitor progress or encouraging self-assessment. Furthermore, the use of lesson study (Fernandez, 2002) and/or action research strategies (Cennamo et al., 2010) may provide teachers with the kind of evidence they need to convince administrators that these technology uses are helping students learn.

In addition to creating a shared vision and building a supportive culture to encourage innovation, schools must also provide adequate resources to support successful technology use. Undoubtedly, lack of resources can be a barrier to teacher technology use (Hew & Brush, 2007). When building a supportive infrastructure, it is important that schools be well equipped, not only with ICT resources, but with the pedagogical expertise needed to facilitate meaningful uses (Somekh, 2008).

Summary of inservice teacher change. Unlike preservice teachers, inservice teachers engage in current practices based on their existing knowledge, self-efficacy, pedagogical beliefs, and the culture of their schools. Although certain components (such as pedagogical beliefs and knowledge) are fairly well formed among experienced teachers and therefore difficult to change, the upside is that inservice teachers have specific contexts within which to work. In other words, because inservice teachers have had more time to develop their beliefs, they may be more aware of them. Also, because teachers work within specific contexts, situated professional development can more readily target teachers' specific needs, building self-efficacy and eliminating some of the barriers related to school culture.

Specifically, in this section we have suggested that teacher professional development programs incorporate several of the following ideas:

1. Align experiences with existing pedagogical beliefs and knowledge
2. Provide examples of other teachers' successes emphasizing student outcomes
3. Provide support for risk-taking and experimentation
4. Expand the definition of "good teaching" to include technology integration (see Table 1, p. 266)

In general, inservice teachers must consider a multitude of variables when incorporating new innovations, such as technology, into their classrooms.

According to Guskey (1995), the amount of change individuals are asked to make is inversely related to their probability of making the change. Facilitating small changes within teachers' own contexts appears to be an effective long-term strategy for impacting teacher practice in big ways.

Conclusion

Educational reform efforts have consistently purported student-centered practices as the most effective way to prepare our students for the 21st century (Voogt, 2008). These reform efforts are based on a new definition of "good" teaching—that is, teaching that facilitates student learning by leveraging relevant ICT resources as meaningful pedagogical tools. Implementing a new definition of effective teaching requires teacher knowledge change, teacher beliefs change, and teacher culture change. Furthermore, teachers need to "own" this new definition. Involving teachers in the visioning process, either through teacher participatory efforts or through teacher education and professional development efforts, is essential. Finally, the cultures in which teachers learn and work must embrace and nurture this new definition.

Once this new definition has been established, teachers need to see examples of what this kind of teaching looks like in practice. Although some may have built relevant knowledge and beliefs from previous experiences (Ertmer, 2005), they may not understand how these ideas translate into practice. Although teachers may wholeheartedly accept this new definition of good teaching, they may be unable to implement it without concrete examples of what this looks like. Therefore, examples become an important strategy to facilitate both teacher knowledge and belief change (Zhao & Cziko, 2001).

Continuing with this idea, it is critically important that teachers believe in their own abilities to implement these changes within their schools and subject cultures. Even if teachers change their pedagogical beliefs to adopt this new notion of good teaching and gain the knowledge to implement it, they still need confidence to implement it within their specific contexts. Providing opportunities for teachers to both experiment and to succeed is important. Schools can support this initiative by creating a culture that allows teachers to try out new practices, while making technical and pedagogical support readily available (Smoekh, 2008).

Perhaps one of the best ways to support teacher change is by providing opportunities for them to witness how the change benefits their students. Borko and Putnam (1995) indicated that professional development cannot, on its own, make teachers change: "The workshops alone did not change these teachers. It was listening to their own students solve problems that made the greatest difference in their instructional practices" (p. 55). Research by Ottenbreit-Leftwich (2007) also demonstrated that when teachers witnessed the impact of technology on their students' learning, they were motivated to experiment with additional technologies in their teaching.

As noted earlier, the most important feature of a professional development program is a strong focus on helping teachers understand how students learn specific content and how specific instructional practices support that learning (Kanaya et al., 2005). Specifically, we must focus our change efforts on helping teachers understand how student-centered practices, supported by technology, affect student learning outcomes. This, then, has the potential to affect substantial changes in knowledge, beliefs, and culture. Once teachers' mindsets have changed to include the idea that teaching is not effective without the appropriate use of ICT resources to achieve student learning outcomes, we will have reached a significant milestone.

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