Teacher Technology Change: How knowledge, beliefs, and culture intersect

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Recent national (CDW-G, 2006) and international (Voogt, 2008) reports paint a promising picture of classroom teachers’ current efforts to use technology to support student learning. For example, among the 1000 teachers who responded to the Teachers Talk Tech survey, 790 teachers (79%) self-reported using computers “to teach students” (CDW-G). However, other research, resulting from both large (Project Tomorrow, 2008) and small-scale (Bauer & Kenton, 2005) efforts, suggests that we still haven’t solved the “problem” of technology integration (Mueller, Wood, Willoughby, Ross, & Specht, 2008) either in the US or internationally (Kozma, 2003; Tondeur, van Braak & Valeke, 2007a; Smeets, 2005). That is to say, technology is not being used to support the kinds of instruction (e.g., student-centered) believed to be most powerful (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 (van Braak, Tondeur, & Valeke, 2004). In response to the Teachers Talk Tech survey (CDW-G, 2006), 88% of the teachers reported using technology for administrative tasks, while 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’ personal uses of the computer are increases in the reported 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” (Russell, Bebell, O’Dwyer, & Kathleen, 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, & Valeke, 2007b). Based on the results of the Speak Up 2007 national survey (Project Tomorrow, 2008), 51% of the teachers (n = 13027 / 25,544) reported that their primary uses of technology to “facilitate student learning" comprised 1) asking students to complete homework assignments using the computer (e.g., writing reports, finding information on the Internet) and 2) assigning practice work at the computer (e.g., using drill and practice software). This is verified, to some extent, by the large percentage of students (grades 6-12), taking the same survey, who reported using technology to 1) write assignments (74%), 2) conduct online research (72%), and check assignments or grades online (58%).

Technology Integration for 21st Century Learners

It is no longer appropriate to suggest that these types of uses 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). And while
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, emphasis added), current data from classroom observations (Andrew, 2007; Bauer & Kenton, 2005; Schaumburg, cited in Schulz-Zander, Pfeifer, & Voss, 2008) do not support this view. 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 (i.e., learning that enables students to construct deep and connected knowledge). While “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.

**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 ICT (information and communication technologies) resources as meaningful pedagogical tools? Following this we ask, How can schools support teachers’ efforts?

“Teachers have been shown to be conservative as a group. They tend to rely on traditional teaching methods and ‘reflexively resist’ curricular and instructional innovation” (Ponticell, 2003, p. 15). Although teachers might believe that technology helps them accomplish professional and/or personal tasks more efficiently, they are hesitant 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/culture in which teachers work often
constraints or limits individual efforts (Roehrig, Kruse, & Kern, 2007; Somekh, 2008). We discuss each of these variables in more detail.

Knowledge as a Key Variable

Teacher knowledge has been shown to have a significant impact on teachers’ decisions:

Teachers’ thinking is directly influenced by their knowledge. Their thinking, in turn, determines their actions in the classroom. Thus, to understand teaching, we must study teachers’ knowledge systems; their thoughts, judgments, and decisions; the relationships between teachers’ knowledge systems and their cognitions; and how these cognitions are translated into action. Similarly, 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 advanced by Lee 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 which, 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, then, is that when teacher educators and inservice and preservice teachers think about what they need to know to be good teachers, technology is not even considered (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. While 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.”

In order to use technology effectively in the classroom, 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 TPCK (technological pedagogical content knowledge; AACTE, 2008; Pierson, 2001), PTICK (pedagogical technology integration content knowledge; 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 all 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 gain knowledge about 1) the technology tools, themselves, and 2) the specific affordances of each tool that, when used to teach content, enable difficult concepts to be learned more readily.

First, teachers need knowledge of the technology itself. “Technological literacy has fast become one of the basic skills of teaching” (Lawless & Pellegrino, 2007, p. 580). If teachers are going to be able 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 standards (ISTE, 2008), which were first published in 1998. Since that time, 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 are, or have been, expected to gain these skills through other means (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, simply knowing how to use a piece of hardware (e.g., digital camera) or a specific software application (e.g., presentation tool, social networking site) isn’t enough to enable teachers to use the technology effectively in the classroom. In fact, if this were true, there’d 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 a pedagogical 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 technology-related management skills can inhibit technology integration.

To use technology to support student-centered instruction, 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 students’ learning. For example, as teachers involve their students in more interdisciplinary work, their content knowledge will need to grow. Pedagogical knowledge will also need to expand to include ideas about how to “develop students’ abilities to work collaboratively or to take control of their own learning in a ICT-rich environment” (Webb & Cox, 2003, p. 277). Finally, teachers will 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 will 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), in order for “optimal” technology integration to occur, teachers need to know how to:

1. Identify which technologies are needed to support specific curricular goals
2. Specify how the tools will be used to help students meet and demonstrate those goals
3. Enable students to use appropriate technologies in all phases of the learning process including exploration, analysis, and production
4. 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 changing. This may result 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 Beliefs as a Key Variable**

Although knowledge of technology is necessary, it won’t be enough if teachers don’t 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 a difference between the number of technology-using teachers who rated themselves highly confident (n=14) and those who rated themselves as highly skilled (n=9). In a survey of 764 teachers, Wozney, Venkatesh, and Abrami (2006), found that one of 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 facilitate student learning.

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).

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); and participating in a professional learning community (Putnam & Borko, 2000). In addition, because “innovation and adaptation are costly in terms of the time needed to develop and establish new practices” (Hennessy, 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 many connections are often referred to as core or central beliefs as many other beliefs are based on, or have been shaped by, these 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 will be the most difficult to change, as their connections to other beliefs will likely 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 they observed. In general, teachers with more traditional beliefs implement more traditional or ‘low-level’ technology uses, while teachers with more constructivist beliefs implement more student-centered or ‘high-level’ technology uses (Judson, 2006; Roehrig et al., 2007). Hermans and his colleagues actually found that “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” (Hennessy et al., 2005, p. 186) as teachers incorporate more technology into their practices. Hennessy et al. described a “gradual but perceptible shift in subject practice and thinking” (p. 186). Other researchers have reported similar findings (Hooper & Reiber, 1995; Levin & Wadmay, 2005; Mills & Tischner, 2003; Windschitl & Sahl, 2002). In a ten-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 beliefs (Sandholtz & Ringstaff, 1996; Sandholtz, Ringstaff, & Dwyer, 1997).

In addition to these pedagogical beliefs, there are additional 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 areas, teachers are unlikely to incorporate it into their pedagogical practices. Hughes (2005) noted “the more content-specific the example, the more likely the teacher will see value and learn it” (p. 295).

Tillema (1995) suggested that beliefs act as a lens or filter when processing new information such as that obtained from textbooks, from knowledgeable others, or even from experience. According to Nespor (1987), early events (especially if particularly unique or vivid) can color our perceptions of subsequent events. Thus, new information delivered through professional development programs is filtered through teachers’ belief systems before being organized into their 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 impacted 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; in order for teachers to incorporate new software or approaches into their existing knowledge structures, the uses first had to align with current beliefs (Hughes, 2005; Kanaya et al., 2005; Zhao & Frank, 2003).

Although beliefs can influence knowledge acquisition and use of technology, context can also play a hefty 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 teachers’ technology uses were strongly influenced by beliefs, but these beliefs were shaped by the context of their institutions and profession: “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 are probably all familiar with 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 innovative teachers are easily overpowered by the 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 inter-locking cultural, social and organizational contexts in which they live and work” (Somekh, 2008, p. 450).

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 meme, which he defined as an “internal representation of knowledge that results in outward effects on the world” (p. 28). (Dictionary.com defines is as a cultural item 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, p. 48).

The pressure to belong doesn’t disappear after the tumultuous adolescent years, but reappears in the form of norms, values, and shared beliefs among individuals in both 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 (Hennessey et al., 2005). 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., 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 perceptions of a negative undercurrent from veteran teachers toward such practices, discouraged novices from integrating technology into 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 wouldn’t. Somekh (2008) described three schools (from 3 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. 457-58). Additionally, all three schools were noted as having these characteristics:

1. Schools were well-equipped with ICT
2. Focus was on changing the process of learning using ICT
3. Skills were acquired as part of the process of using them purposefully
4. Support was provided
5. Teachers had opportunities to discuss problems with peers and facilitators and explore solutions over time
6. Nature of students’ learning changed along with the established epistemologies

If a school doesn’t have these characteristics, it’s still possible that meaningful technology uses can be initiated and supported by the subject culture to which a teacher belongs, although this is more likely to be true at a middle or high school level 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 that which exists in schools), technology use was considered “low risk” as long as it was used in “approved” ways, that is, sanctioned by an expert, or person in authority. Although in most elementary or primary schools this authority would reside with the principal, in middle and high schools this role is often shared with the leader of a discipline- or grade-level team.

The take-away 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 1) his/her personal capabilities and 2) 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, the specific action is likely to be halted, or not even undertaken at all.
The Intersection of Knowledge, Beliefs, and Culture:  
Implications for Practice

Literature related to teacher change, specifically related to technology integration, has focused extensively on the variables discussed here: knowledge, self-efficacy and 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 over the long term. Helping teachers achieve the types of changes we’ve described will require a two-pronged approach – one that addresses these changes during our teacher education programs and one that addresses them during professional development programs for practicing teachers. In this way, both sets of teachers can benefit from, and contribute to, these new visions for teaching and learning. In the next section, we provide specific suggestions for facilitating changes in teachers’ knowledge, confidence, and beliefs that we believe can create a sustainable culture of 21st century teaching and learning.

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). While 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 in an instructional manner. Furthermore, they 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 “good teaching.” As much as possible, definitions need to include the expectation that technology as a tool, process, or method will be an integral component. While 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 1) how to facilitate these types of learning outcomes among their future students, and 2) how to use technology in support of these goals. 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 knowledge they need is to provide opportunities for them to observe a variety of examples and models (Albion, 2003; Ertmer et al., 2003; Zhao & Cziko, 2001). These models can be provided by methods faculty during teacher education courses, as well as 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.

*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.

First, preservice teachers need to be given opportunities to use technology as an instructional tool. This can be accomplished both within the college classroom (micro-teaching, simulated lessons), and in 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 also 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. But observing successful others can also 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 (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 impacts 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 about the importance of technology during students’ 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? If technology is going to be part of students’ images of good teaching, it needs to be pervasive throughout their programs. Then, when students are planning their own lessons, they will automatically incorporate the tools they’ve seen used.

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 are more likely to fall into the “least effective” category 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 – 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 which negate or undermine the new knowledge, confidence, and beliefs they’ve gained. Prior to graduating, teacher educators might engage their preservice teachers in discussions about ways to handle these pressures. For example, 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. Having a supportive mentor is known to help acclimate new teachers into the school culture, without pressuring them to conform (Brown & Warschauer, 2006).

**Implications for Professional Development**

Inservice teachers have a multitude of variables to consider when incorporating new innovations, such as technology, into their practices. According to Guskey (1995), the magnitude of change individuals are asked to make is inversely related to their likelihood of making the change. Therefore, an overall recommendation echoed through each section below is that of facilitating small changes as a long-term strategy for impacting teacher practice in big ways.
Affecting knowledge change. Unlike preservice teachers, inservice teachers have existing pedagogical content knowledge (PCK) on which to build. What is missing, however, is specific knowledge about how the technology, itself, works and how it interacts with PCK to support students’ content learning. Based on their review of the literature, Hew and Brush (2007) concluded that effective professional development for technology integration requires a focus on content that includes 1) technology knowledge and skills; 2) technology-supported pedagogy knowledge and skills (the ability to see a clear connection between the technology being used and the subject content being taught); and 3) 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 the learning process.

The interaction between technology and PCK is most easily achieved by using teachers’ existing knowledge as a springboard. That is, effective professional development will 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). However, this approach can be challenging, especially since it takes more time to individually design technology uses and professional development that cater to the needs of individual teachers.

Another critical variable, noted above, is the need to know how to manage a technology rich classroom (Hew & Brush, 2007). When teachers encounter a new innovation like technology, they may revert back to novice practices. For example, Pierson (1999) studied one experienced teacher who was a novice technology user. Although this teacher typically implemented student-centered practices in her classroom, when she taught technology-related lessons, she became much more teacher-directed. The results from additional longitudinal studies have shown that this shift from teacher-directed to student-centered practice requires extended periods of time (e.g., Sandholtz et al., 1997). However, based on the results of their research, Kanaya et al. (2005) reported that the probability of implementing new technology-rich activities in the classroom was 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 upfront.

Affecting self-efficacy belief change. Even if inservice teachers know how to use technology in their classrooms, they may still lack the confidence needed to actually use it in their classrooms (Mueller et al., 2008). As noted earlier, 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 using
technology. One way to accomplish this is through sharing their success stories, which could be facilitated during staff meetings.

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) in 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 try out new technology ideas 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 pressure when they fail, and are more likely to try new ideas in their classrooms (Brinkerhoff, 2006). Christensen (2002) suggested a need for ongoing technology integration education to reduce teachers’ anxiety levels.

_Affecting pedagogical belief change._ Beliefs formed early in life are very resistant to change; in fact, preconceived beliefs can remain virtually unchanged over time, experiences, and education (Pajares, 1992; Roehrig et al., 2007). 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 successful experiences have a strong influence on the development of their technology integration abilities (Ertmer, Ottenbreit-Leftwich, & York, 2006). Others have found that negative experiences (both personal and vicarious) also impact teachers’ belief systems (Abbott & Faris, 2000; Hazzan, 2003). However, even in the most intensive professional development programs, changes in beliefs usually occur for teachers who are predisposed to the goals of the professional development program (Holt-Reynolds, 1992; Krajcik et al., 1994; Richardson, 1996).

If teachers are going to adopt new beliefs about teaching and learning, they need to understand what these beliefs mean to the students in their classrooms. How are these beliefs translated into practice and how do they impact student learning? Part of the process of changing beliefs relates to helping teachers envision how these beliefs are applied in practice. As suggested by Zhao and Cziko (2001), observing successful others can increase teachers’ perceived need for change, as well as increase their understanding 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. In order to adopt technology as an innovation, teachers need to be willing to take risks, remain flexible, and be open to change (Dexter & Greenhow, 2003; 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 actually to change beliefs and practice (Brinkerhoff, 2006; Borko & Putnam; Ertmer, 2005; Ringstaff & Yocam, 1994).

**Affecting culture change.** In general, teachers’ beliefs and practices shift to align with the current school culture (Zhao & Frank, 2003). Therefore, school leadership is a critical factor in facilitating teacher change. One of the primary roles of the school leadership, then, is to support teachers and create a shared vision for technology use. This shared vision should place emphasis on including technology as part of the definition of “good” teaching. This can be achieved by creating standardized expectations that are articulated through professional development plans that include a technology component. Giving teachers an opportunity to engage in professional goal setting, specifically related to technology, is important as well (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 through specific procedures.

In addition to creating a shared vision and building a supportive culture, 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). However, in 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).

**Conclusion**

Teacher change is a multi-faceted endeavor impacted by teacher knowledge, teacher beliefs, as well as the culture within which teachers work. To encourage or facilitate change requires efforts on all fronts including teacher education programs, teacher professional development, leadership and administration, and including the individual teachers themselves. It is hoped that the suggestions in this paper can help us determine where to focus our efforts to most effectively facilitate that change.

Educational reform efforts have consistently purported student-centered practices as the most effective instruction 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 revolves around student-centered practices and that leverage relevant ICT tools and resources as meaningful pedagogical tools. Implementing a new definition of effective teaching requires teacher knowledge change, teacher beliefs change, and teacher culture change. Furthermore, this new definition needs to be “owned” by teachers; involving teachers in the visioning process is essential either through teacher participatory efforts or through teacher education and professional development efforts. Finally, this new definition must be embraced and enforced by the cultures in which teachers learn and work.
Once this new definition has been established, teachers need to see examples of what this kind of teaching looks like in practice. While 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 these new views of good teaching, they may be unable to implement them without concrete examples of what this looks like. Therefore, examples become an important tool 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 school 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 require 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 help teachers change is to help them 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). 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 the learning process (Kanaya et al., 2005). Specifically, we must focus our change efforts on helping teachers understand how student-centered practices, supported by technology, impact student learning. 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,” we will have reached a significant milestone.
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