# Addressing first- and secondorder barriers to change: Strategies for technology integration.Educational Technology Research and Development, 47(4), 47-61

**Article** *in* Educational Technology Research and Development · December 1999

DOI: 10.1007/BF02299597



**1 author:**

Peggy A. Ertmer
Purdue University

# Addressing First- and Second-Order Barriers to Change: Strategies for Technology Integration

□ Peggy A. Ertmer

*Although teachers today recognize the importance of integrating technology into their curricula, efforts are often limited by both external (first-order) and internal (second-order) barriers. Traditionally, technology training, for both preservice and inservice teachers, has focused on helping teachers overcome first-order barriers (e.g., acquiring technical skills needed to operate a computer). More recently, training programs have incorporated pedagogical models of technology use as one means of addressing second-order barriers. However, little discussion has occurred that clarifies the relationship between these different types of barriers or that delineates effective strategies for addressing different barriers. If pre- and inservice teachers are to become effective users of technology, they will need practical strategies for dealing with the different types of barriers they will face. In this paper, I discuss the relationship between first- and second-order barriers and then describe specific strategies for circumventing, overcoming, and eliminating the changing barriers teachers face as they work to achieve technology integration.*

□ Despite the fact that computing power has become "more available and affordable than ever before" (Means & Olson, 1997, p. 1), little change has occurred in the way schools conduct their daily business (Cuban, 1993; Office of Technology Assessment (OTA), 1995; Tobin & Dawson, 1992). Even as millions of dollars are being pumped into our schools, ensuring that every classroom will be multimedia-equipped and Internet-connected (U.S. Department of Education, 1998), only 5% of the K–12 teaching force is estimated to effectively integrate technology into everyday practice (Parks & Pisapia, 1994). According to Hativa & Lesgold (1996), "There is substantial survey evidence that, almost three decades after the computer was first introduced in schools, it has not brought about a widespread revolution in methods of teaching or in school structure and organization" (p. 134). Hadley and Sheingold (1993) reported similar findings: "For the most part computers . . . provide either an add-on activity or are simply technological versions of the workbook approaches that are already prevalent in the nation's classrooms" (p. 265).

Early models of educational change implied that if teachers had access to enough equipment and training, classroom integration would follow (cf., Apple Classrooms of Tomorrow; Fisher, Dwyer, & Yocam, 1996). Although this may have been true for earlier innovations, computer technology is not as readily assimilated into teachers' existing routines, typically requiring change along multiple dimensions of practice (e.g., personal, organizational, pedagogical). In general, the more integrated one's technology use becomes, the more fundamental the required changes (Kerr, 1996; Sandholtz, Ringstaff, & Dwyer, 1997). Whereas initial, supplemental uses may require small changes in

ETR&D, Vol. 47, No. 4, 1999, pp. 47–61 ISSN 1042–1629

classroom management and organizational strategies, more extensive uses tend to challenge traditional classroom culture as well as teachers' beliefs about the teaching-learning process (Ertmer, Addison, Lane, Ross, & Woods, 1999; Means & Olson, 1997; Sarason, 1996).

Although most teachers today are quick to recognize the importance of using technology in their classrooms (Roblyer, 1993), numerous barriers can block implementation efforts. These barriers range from personal fears (What will I do if the technology fails and my lesson can't proceed? How will I gain the confidence I need?) to technical and logistical issues (How does this software package work? Where or when should I use computers?) to organizational and pedagogical concerns (How can I ensure that students obtain adequate computer time without missing other important content? How do I weave computers into current curricular demands?). Although teachers may not face all of these barriers, the literature suggests that any one of these barriers alone can significantly impede meaningful classroom use (Hadley & Sheingold, 1993; Hannafin & Savenye, 1993; Hativa & Lesgold, 1996).

Brickner (1995) extended the concept of first- and second-order change (Cuban, 1993; Fullan & Stiegelbauer, 1991) to categorize these obstacles as first- and second-order *barriers* to change. First-order changes "adjust" current practice, in an incremental fashion, making it more effective or efficient, while leaving underlying beliefs unchallenged (for example, using the computer, rather than a worksheet, for basic skills review). On the other hand, second-order changes confront fundamental beliefs about current practice, thus leading to new goals, structures, or roles (for example, electronically conversing with an author to explore the cultural and political context of a story rather than writing a book report summary). Barriers to change are "the extrinsic and intrinsic factors that affect a teacher's innovation implementation efforts" (Brickner, p. xvii). Thus, *first-order barriers* to technology integration are described as being extrinsic to teachers and include lack of access to computers and software, insufficient time to plan instruction, and inadequate technical and administrative support. In contrast, *second-order barriers* are intrinsic to teachers and include beliefs about teaching, beliefs about computers, established classroom practices, and unwillingness to change. While many first-order barriers may be eliminated by securing additional resources and providing computer-skills training, confronting second-order barriers requires challenging one's belief systems and the institutionalized routines of one's practice. Thus, in terms of technology integration, this may require reformulating basic school culture notions regarding what constitutes content and content coverage, what comprises learning and engaged time, and even, what behaviors define "teaching" (Fullan & Stiegelbauer, 1991).

The purpose of this paper is to describe both the first- (incremental, institutional) and second-order (fundamental, personal) barriers that hinder teachers' technology implementation efforts, to explore the relationship between these barriers, and to delineate effective strategies for addressing each type. Now that computers are approaching critical mass in the schools (Barone, 1996; Morrison, Lowther, & DeMeulle, 1999), teachers and teacher educators are turning their attention away from the adoption decision (to use or not to use computers) to the implementation process (when and how to use computers in meaningful ways). It is important that teachers gain technical skills as well as pedagogical knowledge of effective instructional practices that incorporate meaningful uses of technology. Furthermore, teacher educators and their students must be aware of potential implementation blocks and develop "block-busting" strategies that enable them to eliminate or circumvent the changing barriers they face.

Although this papers focuses, specifically, on teachers' agency in changing classroom practice, this is not meant to discount the systemic and cultural nature of the change process. Rather, teachers are viewed as being *key* to the change process, coordinating "fit" from within their individual teaching contexts. As noted by Dexter, Anderson, and Becker (1999), "Although culture and context create norms of teaching practice . . . teachers can choose, within these limits, the approach that works for them. This autonomy provides teachers with choices to adopt, adapt, or reject an instructional reform" (p. 224).

This paper draws on results obtained by the author in a series of school-based studies that examined how and why teachers are using (or not using) technology (Ertmer, in progress; Ertmer et al., 1999; Ertmer & Hruskocy, 1999). Although this paper is not intended to be a research report, many of the concepts proposed throughout this article are illustrated using *teachers'* voices from these previous studies. In this way, we gain insights into teachers' interpretations of how these different barriers affect ongoing efforts to make technology "work" in their individual classrooms.

## DEFINING A VISION OF TECHNOLOGY INTEGRATION

Although educators' definition of technology integration has evolved over the past 30 years from teaching programming, to utilizing drill and practice programs, to building computer literacy, to participating in electronic communities (OTA, 1995), teachers' technology use, in general, has changed very little (Hativa & Lesgold, 1996). Because many pre- and inservice teachers have had little, if any, experience with integrated technology classrooms they typically have few images or models on which to build their own visions of an integrated classroom (Beichner, 1993; Kerr, 1996). Yet teachers' visions may ultimately determine the level of integration they attain (Roblyer, 1993). That is, teachers whose visions are directed toward using technology to improve what they already do are likely to achieve a different level of integration than those whose visions include using technology to "meet emerging needs and satisfy new goals" (Norton & Wiburg, 1998, p. 10).

For example, consider the following descriptions of "integrated classrooms" provided by two inservice teachers:

- [A wholly integrated classroom has] glass-top desks that could be used conventionally as well as available computer access for every student. Machines would run Windows 95™ or Windows NT™ with Office 97™ and Internet access readily available and other software added as necessary. The classroom would have an LCD projector and sound system for classroom presentations [secondary social studies teacher].
- A wholly integrated classroom is one in which students have opportunities to see the connections between subject areas and in which multidisciplinary learning occurs. Teachers are able to work with each other and with students to build connections between subject matter. Block schedules and resources such as the Internet make integrated learning possible. Skills are taught within content areas so they are meaningful instead of isolated [middle school technology coordinator].

Whereas the first vision emphasizes the acquisition of hardware and software, the second vision focuses on opportunities for teaching and learning. In the first vision, technology is the end-goal; in the second example, technology is the means for achieving multidisciplinary learning goals. Thus, depending on which vision we strive to achieve, we will measure our success by either (a) the amount of equipment that has been purchased or (b) the amount of learning that has occurred. Although both visions may contribute to integrated technology use, the emphasis in this paper is on what we do with technology rather than on the kinds of equipment with which we do it. Roblyer (1993) suggested that many of the difficulties researchers note (and teachers experience) in achieving high levels of integration are due, at least in part, to the lack of a clear definition or vision of what this means.

In this paper I adopt a vision of technology integration that is both curriculum-based and future-oriented; that is, one that emphasizes preparing students for the future that *they will inherit*. This is not the same future that you and I prepared for, but one in which the three *R*s are embedded within the three *C*s—communication, collaboration, and creative problem solving (Thornburg, 1997). In this view, technology adds value to the curriculum not by affecting quantitative changes (doing more of the same in less time) but by facilitating qualitative ones (accomplishing more authentic and complex goals).

I propose that it is impossible to determine the level of classroom integration by counting the number of computers available or the number of hours they get used. Rather, integration is better determined by observing the extent to which technology is used to facilitate teaching and learning. Although technology can be used to achieve traditional goals (mastering math facts, increasing word recognition) more efficiently (Fisher, Wilmore, & Howell, 1994), researchers and educators are suggesting that it is more effectively applied to achieve 21st-century goals (Dede, 1998; National Council for Accreditation of Teacher Education, 1997; President's Panel on Educational Technology, 1997). According to Means and Olson (1997) this includes "promoting student learning through collaborative involvement in authentic, challenging, multidisciplinary tasks by providing realistic complex environments for student inquiry, furnishing information and tools to support investigation (collecting, analyzing, displaying, and communicating information), and linking classrooms for joint investigations" (p. 9). Thus, as higher levels of integration are reached, basic skills are learned within the context of answering real questions (e.g., how to arrange the furniture in your room so that floor space is maximized) or solving real problems (e.g., changing current school policies to include a year-round scheduling option). In these types of learning environments, technology serves both as a *tool* that enables a student-centered curriculum as well as a *stage* on which meaningful learning activities can be played out (Salomon & Perkins, 1996).

## BARRIERS TO INTEGRATION

As suggested above, achieving this 21st-century vision in today's classrooms is not a simple task. Despite the fact that technologies have achieved a "substantial" presence in schools (Education Development Center, EDC, 1996), teachers all over the country continue to grapple with both practical and philosophical problems posed by the integration process (Hadley & Sheingold, 1993; Moersch, 1995; OTA, 1995). Even among exemplary users, barriers are reported to exist (Becker, 1993). Although we cannot predict the number, type, or order in which teachers will encounter these barriers, the fact that they will experience a wide range of barriers is almost guaranteed. Yet by being aware of the various barriers they may face, teachers can begin to develop the skills and strategies needed to overcome each of the different types. In the next section, two types of barriers, first- and second-order, are described in more detail. Following a discussion of the relationship between these barriers, a variety of block-busting strategies are described.

### First-order Barriers

As indicated above, the term *first-order barriers* refers to those obstacles that are extrinsic to teachers. Typically, these barriers are described in terms of the types of resources (e.g., equipment, time, training, support) that are either missing or inadequately provided in teachers' implementation environments (Means & Olson, 1997). Because these barriers are easy to measure and relatively easy to eliminate (once money is allocated), the majority of early integration efforts focused on eliminating these barriers (Fisher et al., 1996). The underlying assumption was that once adequate resources were obtained, integration would follow. This supported the additional assumption that the implementation process could not even begin until all the necessary resources were in place (Kerr, 1996). For example, a second-grade teacher explained, "I don't use it (the computer) that much with my kids in the classroom because I have a really hard time accessing it, finding a way to organize it with 23 students and one computer. We just don't do very much" (Ertmer et al., 1999). This teacher believed, as do many others, that technology integration depends on having sufficient access to hardware and software (Means & Olson, 1997).

Although the literature documents that first-order barriers related to access, training, and support *can* create a significant problem for teachers (Means & Olson, 1997; OTA, 1995; Parks & Pisapia, 1994), many teachers and schools have utilized creative strategies to overcome these same barriers. For example, a high school teacher at a private school described how he accumulated a variety of both new and outdated computers to allow his students to develop visual representations of science concepts (e.g., using flowcharting shareware to illustrate the components of a cell; using Swift Brochure Magic software to demonstrate knowledge of volcanoes and earthquakes). Although many teachers might have given up in a similar situation, this teacher continued to obtain new hardware and software through shareware, hand-me-downs, grants, and private donations. Thus in this case, lack of easy access did not translate into a significant barrier (Ertmer, in progress).

Having to deal with numerous first-order barriers simultaneously may frustrate teachers who feel pressured to overcome every barrier before beginning the integration process. When asked to describe the barrier that most significantly impacts integration, they may quickly recite a whole range of problems, apparently regarding every barrier as significant. These "laundry lists" of concerns illustrate the frustration teachers feel, often at the start of the process, when the existence of so many first-order barriers seems overwhelming. In addition, these types of responses may suggest that underlying second-order barriers are also at work. Researchers for the Apple Classrooms of Tomorrow (ACOT; Sandholtz et al., 1997) noted how the reduction or elimination of first-order barriers allowed second-order barriers or issues to surface: "In many ways, the massive introduction of technology forced teachers back into a first-year-teacher mode, starting all over again with issues of classroom management, discipline, role definition, and lesson development" (p. xvi).

## Second-order Barriers

Barriers that interfere with or impede fundamental change are referred to as second-order (Brickner, 1995). These barriers are typically rooted in teachers' underlying beliefs about teaching and learning and may not be immediately apparent to others or even to the teachers themselves (Kerr, 1996). Yet current literature suggests that second-order barriers are common among today's teachers (Hannafin & Savenye, 1993; Kerr, 1996; Riedl, 1995). Moreover, these barriers are often thought to cause more difficulties than first-order barriers (Dede, 1998; Fisher et al., 1996). This may be because they are less tangible than first-order barriers but also because they are more personal and more deeply ingrained. Ritchie and Wiburg (1994) noted that "traditional perceptions of what teaching, learning, and knowledge should look like are major limiting factors to integrating technology" (p. 152).

Granted, not all technology use requires second-order change, especially uses designed to automate existing practice (Dede, 1998). Yet, when technology is integrated into classroom practice in ways described earlier, Kerr (1996) warned that it will require "a radical shift in both teaching style and the teacher's vision of what classroom life is all about. . . . This new vision is one that changes the teacher's role in basic ways, reducing the importance of 'chalk and talk,' increasing the need for sensitivity to individual students' problems and achievements, shifting how classrooms are laid out, how evaluation is conducted, how teachers relate to their colleagues, and a hundred other particulars of daily life in schools" (p. 24).

Kerr's comment alludes to many of the second-order barriers teachers may face when they begin implementing technology in meaningful ways. These barriers relate to teachers' beliefs about teacher-student roles as well as their traditional classroom practices including teaching methods, organizational and management styles, and assessment procedures. Add to this an unclear vision regarding what is expected of them and their students (Baker, Herman, & Gearhart, 1996), as well as a general uncertainty about the relevance of technology in their prescribed curricula (Ertmer et al., 1999), and teachers are likely to experience a severe case of "cultural incompatibility." Cuban (cited in Holloway, 1998) concluded, "It is a belief system, not an economic or empirical warrant, that determines failure or success" (p. 1110).

Thus, even if every first-order barrier were removed, teachers would not automatically use technology to achieve the kind of meaningful outcomes advocated here. "Technologies almost never of themselves cause substantial change in schools" (EDC, 1996, p. 1). Teaching is generally described as a "conservative practice" (LaBoskey, 1994, p. x); that is, certain teaching practices have emerged as "resilient, simple, and efficient in dealing with a large number of students in a small space for extended periods of time" (Cuban, 1986, p. 58). Thus, one of the major stumbling blocks to achieving integration may be, as Sheingold (1991) pointed out, that "teachers will have to confront squarely the difficult problem of creating a school environment that is fundamentally different from the one they themselves experienced" (p. 23). As teacher educators then, our job becomes one of helping our pre- and inservice teachers figure out exactly how to do that (and furthermore, to do so without typically having encountered these environments ourselves!).

It is possible that some teachers will not face second-order implementation barriers (Evans-Andris, 1995; Van Haneghan, & Stofflett, 1995). For example, teachers who have already redefined traditional teacher-student roles, who have organized their classrooms into multidisciplinary teams focused on authentic problems, and who have embraced alternative assessment practices may find that technology fits well into their existing classroom cultures. Still, adding technology to the mix may cause logistical and technical problems to emerge (first-order barriers) that weren't evident before (Means & Olson, 1997). This suggests that first- and second-order barriers may never be eliminated completely but rather that they will continue to ebb and flow throughout the evolutionary integration process (Becker, 1993). At some points, first-order barriers will be at the forefront; at other times, second-order barriers will present the more critical challenges.

## Relationship Between Barriers

Currently the relationship between first- and second-order barriers is not clearly understood. What once was regarded as a relatively simple relationship (e.g., if you eliminate first-order barriers, integration will follow; Fisher et al., 1996) appears much more complex than initially proposed. Many researchers have described how teachers' uses of the computer "evolve" as they gain experience (Hadley & Sheingold, 1993; Marcinkiewicz, 1993; Sandholtz et al., 1997; Willis, 1992), yet it is unclear how this evolution relates specifically to the presence or absence of either first- or second-order barriers. As noted earlier, barriers to effective integration exist at all levels of use (Becker, 1993). Yet questions remain: Do teachers at higher levels of use encounter relatively fewer first- and second-order barriers? In what ways are barriers that are encountered by teachers at higher levels of technology use similar or dissimilar to those encountered by teachers at lower levels of use? How do teachers' approaches to first-order barriers differ based on the existence (or lack) of second-order barriers? Although the verdict is still out on all of these questions, some preliminary thoughts are included below. Further study is needed to clarify and confirm these ideas.

Although we might predict that teachers who have achieved higher levels of use actually encounter fewer first-order barriers, the more significant difference between high- and low-level users may be related to teachers' *perceptions* of the criticality of these barriers. Previous results (Ertmer et al., 1999; Ertmer & Hruskocy, 1999) suggest that the relative *weight* that teachers assign to first-order barriers can lead to different classroom outcomes. For example, teachers with a limited amount of training may begin using technology with current levels of knowledge and skill or wait until sufficient levels have been obtained, depending on how significantly they weight their own lack of training. Furthermore, depending on underlying pedagogical beliefs and current classroom practices (i.e., the relative strength of second-order barriers), those who choose to begin with limited knowledge may initially provide restricted student use until they have mastered skills themselves, or they may empower students to become classroom technology experts and then encourage them to share their expertise with both peers and teachers (Coburn, 1998).

Thus, although the barriers are the same, the consequences may be different. As suggested above, relative weights assigned to first-order barriers may be related, at least in part, to teachers' underlying second-order barriers (Ertmer et al., 1999). For example, limited access may be assigned relatively high weight by teachers who are not convinced that technology is relevant to their curriculum (as illustrated by the second-grade teacher with only one computer). Yet others, who consider technology central to the curriculum (as illustrated by the high-school science teacher), may assign relatively low weight, regarding limited access as an inconvenience, or a challenge, but not a deterrent.

Although second-order barriers may not be readily observed, their presence often can be noted in the *reasons* teachers give for being frustrated by first-order barriers. For example, many teachers may feel that their efforts are constrained by limited equipment, yet their reasons for wanting more computers may point to different goals and beliefs. Whereas some teachers may want more computers so that they can increase their efficiency in covering *current* curricula ("Having more computers would let me do more of the same, but do it more efficiently."—second-grade teacher), others want more so they can extend students' work *beyond* current content ("If I had more computers . . . the curriculum guidelines, the minimum competencies and standards, would be far exceeded."—fifth-grade teacher). Thus, by examining teachers' reasons for feeling frustrated, we can begin to understand how their goals for technology use, as well as their beliefs about the role of technology in the curriculum, may shape perceptions of, and responses to, first-order barriers. Knowing this, educators might better identify effective strategies for helping teachers address both the apparent first-order and underlying second-order barriers they face.

There is some indication in the literature that second-order barriers must be addressed prior to, or at least in conjunction with, the attainment of higher levels of integration (Hannafin & Savenye, 1993; Kerr, 1996). As Riedl (1995) emphasized, "To be good at integrating technology requires a different learning perspective and a meaningful change on the part of the teacher" (p. 141). Yet others (e.g., Dwyer, 1996) have suggested that technology use can prompt second-order changes in teaching practices and beliefs that might not have occurred otherwise. Ritchie and Wiburg (1994) stated that, "Technology's greatest power may be the way in which its use causes teachers, administrators, and students to rethink teaching and learning" (p. 152). These contrasting opinions suggest the possibility that the relationship between teaching beliefs and classroom technology use is interactive, with successive, iterative changes occurring in both (Dwyer, 1996; Griest, 1996).

In summary, it is generally acknowledged that first-order barriers can be significant obstacles to achieving technology integration, yet the relative strength of second-order barriers may reduce or magnify their effects (Ertmer et al., 1999, Miller & Olson, 1994). Based on current evidence (Hannafin & Savenye, 1993; OTA, 1995), we might safely assume that either type of barrier alone can halt implementation efforts. Whereas beliefs (second-order barriers) may impede meaningful use, first-order barriers may hinder actualization of more facilitative beliefs. Since different barriers are likely to appear at different points in the integration process, teachers need effective strategies for dealing with both kinds of barriers.

## STRATEGIES FOR ADDRESSING BARRIERS

Achieving technology integration is a multifaceted challenge that entails more than simply acquiring and distributing computers. Although I propose that different types of barriers require different types of strategies to overcome, I am not proposing that barriers be addressed in a lock-step manner. That is, we should not try to eliminate one first-order barrier before addressing another, or to eliminate all first- (or second-) order barriers prior to addressing barriers at the next level. Because of continual interactions between barriers, it may be more effective to address first- and second-order barriers simultaneously, or at least recursively, as they fluctuate in relative strength throughout the integration process.

In the next section, I describe strategies for helping teachers confront the various barriers they may face during the integration process. Rather than discuss barriers strictly by category, I discuss them in the order in which they are likely to be encountered, thus simulating the interactive, dynamic nature of the barrier-breaking process. When possible, specific tactics are also included as examples of how to translate these ideas into practice. It is important to note that any barrier can be addressed by more than one strategy, and that some strategies effectively address more than one barrier. In addition, although some barriers will require little effort to overcome, others will require persistent use of multiple strategies. Finally, although the next section includes some strategies that, ultimately, must be implemented by others (i.e., by definition, first-order barriers are *external* to teachers), the intent is to increase teachers' understanding of what they can implement themselves and what they might reasonably request and expect from others.

## Developing a Vision

One of the most important steps in achieving meaningful technology use is the development of a vision of how to use technology to achieve important educational goals (Baker et al., 1996; Kerr, 1996; Roblyer, 1993). It is both ineffective and inefficient to address first-order barriers if we do not know what we want to do, first without, and then with, technology (Hooper & Rieber, 1995). As noted by the Office of Educational Research and Improvement (OERI, 1993): "Most teachers will find little incentive to tackle the technical and scheduling problems associated with technology (first-order barriers) unless they have a clear vision of how the technology can improve teaching and learning" (p. 85). A vision gives us a place to start, a goal to reach for, as well as a guidepost along the way. Although we are likely to make adjustments in our vision over time, a shared vision offers a vehicle for coherent communication among all stakeholders (teachers, parents, students, administrators, community leaders, business partners). Thus, when new issues, problems, or opportunities arise, our vision keeps us focused on what is central to our technology efforts.

Means and Olson (1997) recommended that teachers, schools, and districts develop a vision *before* they make substantial investments in hardware and software. Although this may not be possible for many schools that have already amassed a significant number of computers, it is important that teachers and administrators come together to develop a unifying set of goals to direct their current and future efforts. According to Sandholtz et al. (1997), "Teachers need increased and varied opportunities to see other teachers, to confront their actions and examine their motives, and to reflect critically on the consequences of their choices, decisions, and actions. They need opportunities for ongoing dialogue about their experiences and for continuous development of their abilities to imagine and discover more powerful learning experiences for their students" (p. 51). Based on this advice, three main strategies for developing a vision—modeling, reflection, and collaboration—are outlined here. Simply put, teachers need opportunities to observe *models* of integrated technology use, to *reflect* on and discuss their evolving ideas with mentors and peers, and to *collaborate* with others on meaningful projects as they try out their new ideas about teaching and learning with technology. Specific tactics for implementing these strategies are described below.

*Modeling.* Teachers can gain access to models through structured on-site observations of technology-using teachers or via text-, video-, or Web-based case studies of technology-integrating teachers. Demonstrations by peers, mentors, or seasoned practitioners can illustrate effective ways to use technology to teach existing and expanded content. In addition, members of a learning community (administrators, technology coordinators, parents, teachers, students) can become models and mentors for each other. Participation in staff development activities that model meaningful uses of technology can help teachers understand what it takes to translate new visions into classroom practice (David, 1996).

*Reflection.* Reflection among teachers is a critical component of any innovation effort. As Persky (1990) noted, "When teachers engage with each other in ongoing reflection about their use of instructional technology, they are more likely to critically evaluate their practice and redesign instruction to better meet student needs and curricular goals" (p. 37). Reflection is facilitated by providing continual time for teachers to interact with knowledgeable others and to share developing ideas via professional development activities (virtual or real-time). Publishing ideas (via newsletters, electronic journals, conference proceedings) can prompt teachers to articulate beliefs and practices. Furthermore, these publications can elicit readers' questions and responses, thus extending and transforming authors' *and* readers' visions for use.

*Collaboration.* Hadley and Sheingold (1993) stressed that "on-site support and colleagueship are critical ingredients to successful technology integration" (p. 299). Through ongoing conversations with colleagues and experts, engagement in cross-site technology projects, and shared planning time with colleagues, teachers gain access to a wide-ranging supportive network that empowers them first to envision, and then to achieve, meaningful technology use. Gibbons and Norman (1987) suggested that "unless the teacher is developing, development in schooling will not occur" (p. 105). Continual collaboration among teachers offers one way to ensure that this continual visioning and development occur.

### Identifying Curricular Opportunities

Having articulated an overall vision for classroom technology use (e.g., use of authentic challenging, multidisciplinary tasks; promotion of active learning and collaborative work), the next step is to identify specific areas in the curriculum where technology can work. Until recently, this component has been neglected in technology training programs (Gilmore, 1995; Wetzel, 1993). Although most training programs helped teachers increase computer skills at the *mechanical* level, little information or support was provided at the *instructional* level. Thus, teachers completed technology training courses still not knowing how to create or implement activities that incorporated meaningful uses of technology (Moersch, 1995).

On one hand, this dilemma points to a persistent first-order barrier (weaknesses in traditional training programs), although curricular development efforts may also reveal second-order barriers. According to OERI (1993), "Regardless of how extensively technology is used or how state of the art the technology applications being used might be, any technology integration requires that teachers engage in rethinking and reshaping their curriculum" (p. 67). This, then, may bring beliefs and values to the surface, creating difficulties for teachers who are unwilling, or unable, to modify current practices. Furthermore, for curricular change to take hold, teachers will have to determine how to make the change fit with other established components of the system.

Means and Olson (1997) listed three ways that teachers might implement a technology-enhanced curricula: (a) *utilize* an appropriate piece of software (e.g., Carmen SanDiego) within existing instruction, (b) *adapt* a comprehensive multimedia curriculum (e.g., Voyage of the Mimi) to achieve current instructional goals, or (c) *design* a curriculum unit around a theme or topic (e.g., ocean life, space exploration) using a variety of technology applications, generally with an emphasis on tool and communications software. Each of these approaches demands differing amounts of curricular modification as well as different skills on the part of the teacher. Incorporating new software into an existing lesson is perhaps the simplest way for teachers to begin. After initial bugs are worked out, teachers might attempt more extensive curricular changes. Finally, when comfort and competence are relatively high, teachers might design complete units that are embedded with, and enabled by, technology.

Specific tactics for identifying, and effectively utilizing, curricular opportunities include: (a) talking to others at the same grade level, or in the same content area, to share ideas about how and when to use technology, (b) developing creative ways to address logistical and technical problems during early stages of use (e.g., team-teaching; soliciting parent volunteers as classroom helpers; grouping students to include a more knowledgeable student in each group), (c) starting small—incorporating technology into the curriculum, one lesson at a time, and (d) working with others at the school, district, and state levels to incorporate technology competencies into existing curriculum guidelines.

## Obtaining Resources

Lack of adequate resources (first-order barriers) can constrain any integration effort. If teachers do not have sufficient equipment, time, training, or support, meaningful integration will be difficult, if not impossible, to achieve. The following tactics, drawn from the literature as well as from teachers' experiences, address four main resource constraints.

*1. Access.* Greater access can be achieved through fund-raisers, donations, and grants, as well as through the formation of partnerships with businesses, universities, libraries, and community and vocational colleges. While waiting for more hardware or software to arrive, schools might consider maximizing the use of available equipment by centralizing a portion of the equipment (creating a minilab), using roving labs, implementing an "incremental roll-out" plan (adding technology at one level or in one subject area at a time), or distributing available equipment via an inhouse proposal process (Means & Olson, 1997).

*2. Time.* Teachers need time for both professional and curricular development activities (to learn new skills, preview software, explore available resources, create new lessons) if success is to be achieved. School administrators might "buy time" for teachers by using block scheduling, providing monthly or quarterly curriculum-development days, scheduling extended planning time for same-grade–same subject teams, reorganizing teaching loads, or implementing innovative staffing procedures (e.g., use of permanent or roving substitutes, student teachers, parent-grandparent-community volunteers). Whenever possible, districts should also provide time for teachers to participate in training workshops, visit other classrooms, and attend and present at conferences. These professional development activities can help broaden teachers' views as well as build knowledge, skills, and confidence.

*3. Training.* Teachers need access to multiple types of training opportunities including on-site credit courses, after-school short courses, specialized workshops, weekend retreats, and summer intensive courses. It is currently recommended that technology training address both pedagogical and technological needs (Fisher et al., 1996), engaging participants in the same types of projects (and using the same types of applications) that they are encouraged to use in their own classrooms. ACOT researchers (David, 1996; Dwyer, 1996) suggest that technology-training experiences be embedded within authentic activities that engage teachers in relevant collaborative problem-solving tasks. Such an approach provides teachers with both a vision of what teaching-with-technology looks like, and a model of the type of learning experiences we are asking them to create.

Ritchie and Wiburg (1994) recommended that training be regarded as an ongoing, although evolving, need. Districts might consider "growing their own experts" by utilizing local teachers, and in some cases, community members, to design and teach workshops (EDC, 1996). In addition, students and teachers can be paired as workshop participants, thus growing talent at multiple levels simultaneously. Follow-up training can be provided via mentors, on-line experts, student-technology trainers, parents, or local experts. Training impact might be extended through take-home computer programs for students, teachers, or both; newsletters that emphasize classroom applications for specific software applications; and demonstrations that highlight noteworthy accomplishments by local teachers. Finally, by providing ongoing financial support for teachers' attendance at local, state, and national teacher and technology conferences, schools can increase their own training capabilities by accessing experts from across the country.

*4. Support.* For teachers to use technology well, multiple types of support are needed (Ertmer & Hruskocy, 1999) including professional (help in planning for uses and acquisitions; time to plan for and implement innovative uses), technical (training in how to use new hardware and software, on-demand help when problems occur, low-level system maintenance) and instructional (demonstrations or advice on how to incorporate into instruction). As people, schools, and projects mature, however, the relative importance of these functions appears to shift. In the early stages of integration, teachers tend to have a greater need for "deep and reliable" technical backup (EDC, 1996). This can be provided through on-site teacher troubleshooters, part-time coordinators, parent or business volunteers, student assistants, on-line help, and university or business partners. Over time, teachers' technical dependency tends to decrease as they learn first-level problem-solving skills. Once technical competency is gained, however, teachers may feel an increased need for instructional and professional support as they begin exploring new ways to integrate the technology within their classrooms (Browne & Ritchie, 1991). According to EDC (1996), the overall goal is to give teachers enough knowledge and support to confidently continue to explore on their own, but with assured backup when troubles arise.

### Managing Resources and Classroom Activities

Managing technology resources in student-centered classrooms is a difficult task that few teachers have been prepared to handle (Kerr, 1996; Sandholtz, Ringstaff, & Dwyer, 1990). In an integrated classroom, this might include such tasks as rotating students through activities (both computer-based and noncomputer-based), assisting students while on the computer, and maintaining the technology resources themselves (Morrison et al., 1999). As Morrison et al. pointed out, "Computers can be introduced without dramatically changing the instruction, but they cannot be introduced without making immediate shifts in classroom management processes" (p. 78). They cite Sandholtz et al. (1990) in suggesting that "instructional innovation is not likely to occur until teachers have achieved a significant level of mastery over management issues" (p. 78).

Management issues can comprise both first- and second-order barriers. When management problems arise because of the small number of computers, large number of children, or the teachers' lack of knowledge of effective organizational strategies, first-order barriers may need to be addressed. If, on the other hand, management problems occur because teachers prefer to be in control of students' learning, are comfortable with their approach to classroom management, or believe that children need to complete work independently, then second-order barriers may be underlying teachers' difficulties. An elementary principal noted that knowing how to use (and manage) computers presented a formidable challenge for her teachers: "I think availability is our biggest problem and yet maybe not. Maybe expert guidance in what we need to be doing. It could be that we have enough, we're just not using them effectively."

Effective management strategies can help teachers address both first- and second-order barriers. To effectively utilize available resources, teachers might consider ways to rotate students through a single or small number of classroom computers. Tasks might be divided so that each student or small group actually needs only a short amount of time at the computer. Other centers can provide time for planning and additional off-line tasks. When students are working on the computer, Morrison et al. (1999) suggested that teachers can assist with computer skills by providing any or all of the following: initial teacher demonstrations, peer modeling and assistance, technology posters and job aids, and student handouts. When students encounter technology problems, they can be encouraged to "ask a neighbor" or to "try three things" before interrupting the teacher. When teachers assist students with technical problems, they might talk-aloud as they problem solve, thus modeling the troubleshooting process for the students. Students can add troubleshooting tips to a class log or journal, thus assisting others who may have similar problems in the future.

Class rules should also be established regarding how to care for and maintain available resources (e.g., keep hands off the computer monitors). Additional rules can be used to create a "computer learning culture," as described by Ryba and Anderson (1993). These rules include: (a) help one another solve problems, (b) share information and ideas openly, (c) congratulate each other for making progress and maintaining good effort, (d) work closely with others who are working (physically) close to you, (e) support peers who are faced with personal "crises," and (g) support each other beyond the computer environment (p. 5). By following these guidelines, students and teachers can create a manageable environment that supports high levels of learning and student involvement.

### Assessing Student Learning

Assessment provides a necessary and powerful reality check. Monitoring both intended and unintended outcomes affords participants a chance to switch directions, if necessary, and to keep efforts directed toward established educational goals. Teachers need appropriate evaluation strategies for assessing the results of both technology investments and classroom efforts. Learning processes and outcomes, enabled by technology, can be measured through the use of rubrics, electronic portfolios, process-oriented feedback, as well as performance tasks requiring teams of students to solve authentic problems with new technologies. Students should also be required to engage in self-evaluation; that is, to establish learning goals at the start of a unit and to assess their progress throughout the learning process. At the conclusion of the unit, students can determine specific knowledge and skills gained and add personal entries to an electronic log or journal that charts their growth as both learners and technology-users. In this way, the assessment process extends beyond products to include information about students' knowledge, skills, dispositions, and attitudes, as well as their beliefs about subject matter and about learning itself (EDC, 1996).

## CONCLUSION

Integrating technology into the teaching and learning process is a goal that many teachers strive for but which relatively few have achieved to date (Parks & Pisapia, 1994). Whereas some teachers are constrained by first-order barriers, including limited equipment, training, and support, others struggle to overcome second-order barriers including their own deeply held beliefs about teacher-student roles, curricular emphases, and assessment practices. Although it is possible that some teachers will not face either type of barrier, the literature suggests that teachers are likely to face *both* types of barriers as they move toward becoming technology-integrating teachers. (Hadley & Sheingold, 1993; Moersch, 1995; OTA, 1995). As Dexter et al. (1999) explained, "For teachers to implement any new instructional strategy, they must acquire new knowledge about it and then weave this together with the demands of the curriculum, classroom management, and existing instructional skills" (p. 223). As subcogs in a dynamic system, all are integral to turning the gears of the school improvement process (Fullan, 1992).

Given that most teachers today are likely to face numerous barriers as they begin (and continue) implementing technology in their classrooms, it is imperative that they possess practical strategies for circumventing, overcoming and eliminating these barriers. These strategies go beyond finding ways to acquire hardware and software and the basic technical skills needed to operate them. If teachers are to use technology to achieve consequential student outcomes, then they also need skills for designing technology-enhanced curricular units, selecting and adapting software, organizing projects that make use of technology, guiding students in the use of computer-based resources, as well as assessing students' learning in project-based collaborative technology-based work (Means & Olson, 1997). These latter skills require powerful pedagogical strategies, not typically taught in teacher preparation programs (Kerr, 1996). Yet without these skills, and strategies for accomplishing them, teachers may find integrated technology use too distant a goal to achieve.

It is generally acknowledged that traditional technology-training programs do not help teachers acquire the skills needed to use technology in ways that "facilitate fundamental, qualitative changes in the nature of teaching and learning" (President's Panel on Educational Technology, 1997, p. 33). To address these needs, significant changes in the professional preparation of educators are being recommended, including greater emphasis on professional *growth*, as opposed to program-technology adoption (Gilmore, 1995). According to EDC (1996), professional development should be directed toward growing human capacities. "It is not training in the technology but training in how to *leverage* the technology to provide, increase, improve, and/or assess student learning" (p. 8). Thus, rather than focusing on technology per se, professional development experiences might be more effectively linked to new visions for teaching and learning, made possible with technology, rather than the development of user proficiency in the operation of specific software and hardware (EDC, 1996).

Learning to use new technology tools and taking major steps to change one's classroom practices will be a challenge for most teachers. Yet if teachers are prepared to confront both first- and second-order barriers, success will be more likely. As Fullan (1993) noted: "Success in school change efforts is much more likely when problems are treated as natural, expected phenomena. . . . Successful schools do not have fewer problems than other schools—they just cope with them better" (p. 26). By arming our current and future teachers with knowledge of barriers, as well as effective strategies to overcome them, it is expected that they will be prepared to both initiate and sustain effective technology integration practices. □

---

Peggy A. Ertmer is Assistant Professor of Educational Technology at Purdue University. Her e-mail address is pertmer@purdue.edu.

## REFERENCES

Baker, E.L., Herman, J.L., & Gearhart, M. (1996). Does technology work in schools? Why evaluation cannot tell the full story. In C. Fisher, D.C. Dwyer, & K. Yocam (Eds.), *Education and technology: Reflections on computing in classrooms* (pp. 185–202). San Francisco: Jossey Bass.

Barone, C. (1996). Full speed aheadwith caution. *Educom Review, 31*(3). Retrieved December 8, 1998 from the World Wide Web: http://www.educause.edu/pub/er/review/reviewarticles/31324.html

Becker, H.J. (1993). How exemplary computer-using teachers differ from other teachers: Implications for realizing the potential of computers in schools. *Journal of Research on Computing in Education, 26*, 291–321.

Beichner, R.J. (1993). Technology competencies for new teachers: Issues and suggestions. *Journal of Computing in Teacher Education, 9*(3), 17–20.

Brickner, D. (1995). *The effects of first and second order barriers to change on the degree and nature of computer usage of secondary mathematics teachers: A case study.* Unpublished doctoral dissertation, Purdue University, West Lafayette, IN.

Browne, D.L., & Ritchie, D.C. (1991). Cognitive apprenticeship: A model of staff development for implementing technology in schools. *Contemporary Education, 63*(1), 28–34.

Coburn, J. (1998). Kids in charge. *Technology and Learning, 19*(1), 24–36.

Cuban, L. (1986). *Teachers and machines: The classroom use of technology since 1920.* New York: Teachers College Press.

Cuban, L. (1993). Computers meet classroom: Classroom wins. *Teachers College Record, 95*, 185–210.

David, J.L. (1996). Developing and spreading accomplished teaching: Policy lessons from a unique partnership. In C. Fisher, D.C. Dwyer, & K. Yocam (Eds.), *Education and technology: Reflections on computing in classrooms* (pp. 237–250). San Francisco: Jossey Bass.

Dede, C. (Ed.) (1998). *Learning with technology: The 1998 ASCD Yearbook.* Alexandria, VA: Association for Supervision and Curriculum Development.

Dexter, S.L., Anderson, R.E., & Becker, H.J. (1999). Teachers' views of computers as catalysts for changes in their teaching practice. *Journal of Research on Computing in Education, 31*, 221–238.

Dwyer, D.C. (1996). The imperative to change our schools. In C. Fisher, D.C. Dwyer, & K. Yocam (Eds.), *Education and technology: Reflections on computing in classrooms* (pp. 15–33). San Francisco: Jossey Bass.

Education Development Center (1996). National study tour of district technology integration summary report (CCT Reports, No. 14). New York: Center for Children and Technology.

Ertmer, P.A. (in progress). *Helping Teachers Envision and Achieve Technology Integration through the Use of Exemplary Peer Models.* Research and Development Project funded by the Multimedia Instructional Development Center, Purdue University, West Lafayette, IN.

Ertmer, P.A., Addison, P., Lane, M., Ross, E., & Woods, D. (1999). Examining teachers' beliefs about the role of technology in the elementary classroom. *Journal of Research on Computing in Education, 32*(1), 54–72.

Ertmer, P.A., & Hruskocy, C. (1999) Impacts of a university-elementary school partnership designed to support technology integration. *Educational Technology Research and Development, 47*(1), 81–96.

Evans-Andris, M. (1995). An examination of computing styles among teachers in elementary schools. *Educational Technology Research and Development,* 43(2), 15–31.

Fisher, C., Dwyer, D.C., & Yocam, K. (Eds.). (1996). *Education and technology: Reflections on computing in classrooms.* San Francisco, Jossey-Bass.

Fisher, C., Wilmore, F., & Howell, R. (1994). Classroom technology and the new pedagogy. *Journal of Computing in Childhood Education 5,* 119–129.

Fullan, M. (1992). *Successful school improvement.* Bristol, PA: Open University Press.

Fullan, M. (1993). *Changing forces: Probing the depths of educational reform.* London: Falmer Press.

Fullan, M., & Stiegelbauer, S.M. (1991). *The new meaning of educational change.* New York: Teachers College Press.

Gibbons, M., & Norman, P. (1987). An integrated model for sustained staff development. In M.F. Wideen & I. Andrews (Eds.), *Staff development for school improvement: A focus on the teacher* (pp. 103–110). London: Falmer Press.

Gilmore, A.M. (1995). Turning teachers on to computers: Evaluation of a teacher development program. *Journal of Research on Computing in Education, 27,* 251–269.

Griest, G. (1996). Computer education as an obstacle to integration and internetworking. *Learning and Leading with Technology, 23*(7), 31–34.

Hadley, M., & Sheingold, K. (1993). Commonalties and distinctive patterns in teachers' integration of computers. *American Journal of Education, 101,* 261–315.

Hannafin, R.D., & Savenye, W.C. (1993). Technology in the classroom: The teachers new role and resistance to it. *Educational Technology, 33*(6), 26–31.

Hativa, N., & Lesgold, A. (1996). Situational effects in classroom technology implementations: Unfulfilled expectations and unexpected outcomes. In S.T. Kerr (Ed.), *Technology and the future of schooling: Ninety-fifth Yearbook of the National Society for the Study of Education, part 2* (pp. 131–171). Chicago: University of Chicago Press.

Holloway, R.E. (1998). Diffusion and adoption of educational technology: A critique of research design. In D.J. Jonassen (Ed.), *Handbook of research in educational technology* (pp. 1107–1133). City, State: Macmillan.

Hooper, S., & Rieber, L. (1995). Teaching with technology. In A.C. Ornstein (Ed.), *Theory into practice* (pp. 155–170). Boston: Allyn and Bacon.

Kerr, S.T. (1996). Visions of sugarplums: The future of technology, education, and the schools. In S.T. Kerr (Ed.), *Technology and the future of schooling: Ninety-fifth yearbook of the National Society for the Study of Education,* (part 2), pp. 1–27. Chicago: University of Chicago Press.

LaBoskey, V.K. (1994). *Development of reflective practice: A study of preservice teachers.* New York: Teachers College Press.

Marcinkiewicz, H.R. (1993). Computers and teachers: Factors influencing computer use in the classroom. *Journal of Research in Computing in Education, 26,* 220–237.

Means, B., & Olson, K. (1997). *Technology and education reform: Studies of education reform.* Washington, DC: U.S. Government Printing Office.

Miller, L., & Olson, J. (1994). Putting the computer in its place: A study of teaching with technology. *Journal of Curriculum Studies, 26,* 121–141.

Moersch, C. (1995). Levels of technology implementation (LoTi): A framework for measuring classroom technology use. Learning and Leading with Technology, 23(3), 40–41.

Morrison, G.R., Lowther, D.L., & DeMeulle, L. (1999). Integrating computer technology into the classroom. Upper Saddle River, NJ: Merrill/Prentice Hall.

National Council for Accreditation of Teacher Education (1997). Technology and the new professional teacher: Preparing for the 21st century (On-line). Available: http://www.ncate.org (February 4, 1998).

Norton, P., & Wiburg, K.M. (1998). *Teaching with technology.* Orlando: Harcourt Brace.

Office of Educational Research and Improvement (1993). *Using technology to support education reform.* Washington, DC: U.S. Government Printing Office.

Office of Technology Assessment (1995). *Teachers and technology: Making the connection.* Washington, DC: U.S. Government Printing Office.

Parks, A., & Pisapia, J. (1994). Developing exemplary technology-using teachers: Research Brief #8. Metropolitan Educational Research Consortium, Richmond, VA. ERIC Reproduction Document No: 411 360.

Persky, S.E. (1990). What contributes to teacher development in technology? *Educational Technology, 30*(4), 34–38.

President's Panel on Educational Technology. (1997). *Report to the President on the use of technology to strengthen K-12 education in the United States.* Washington DC. U.S. Government Printing Office.

Riedl, J. (1995). *The integrated technology classroom: Building self-reliant learners.* Boston: Allyn and Bacon.

Ritchie, D., & Wiburg, K. (1994). Educational variables influencing technology integration. *Journal of Technology and Teacher Education, 2*(2), 143–153.

Roblyer, M.D. (1993). Why use technology in teaching? Making a case beyond research results. *Florida Technology in Education Quarterly, 5*(4), 7–13.

Ryba, K., & Anderson, B. (1993). *Learning with computers: Effective teaching strategies.* Eugene, OR: International Society for Technology in Education.

Salomon, G., & Perkins, D. (1996). Learning in Wonderland: What do computers really offer education? In S.T. Kerr (Ed.), Technology and the future of schooling: *Ninety-fifth yearbook of the National Society for the Study of Education, part 2* (pp. 111–130). Chicago: University of Chicago Press.

Sandholtz, J.H., Ringstaff, C., & Dwyer, D.C. (1990). Teaching in high tech environments: Classroom management revisited, first-fourth year findings. Apple Classrooms of Tomorrow Research Report Number 10. (On-line). Available: http://www

.research.apple.com/Research/proj/acot/full/acotRpt10full.html

Sandholtz, J.H., Ringstaff, C., & Dwyer, D.C. (1997). *Teaching with technology: Creating student-centered classrooms.* New York: Teachers College Press.

Sarason, S.B. (1996). Revisiting "The culture of the school and the problem of change." New York: Teachers College Press.

Sheingold, K. (1991). Restructuring for learning with technology: The potential for synergy. Phi Delta Kappan, 73(1), 17–27.

Thornburg, D.D. (1997). 2020 visions for the future of education. Retrieved October 21, 1998 from the World Wide Web: http://www.tcpd.org/handouts/thornburg/2020visions.html

Tobin, K., & Dawson, G. (1992). Constraints to curriculum reform: Teachers and the myths of schooling. Educational Technology Research and Development, 40(1), 81–92.

U.S. Department of Education, Office of Educational Technology. (1998). The President's technology initiative. Retrieved October 20, 1998 from the World Wide Web: http://www.whitehouse.gov/WH/EOP/edtech/html/edtech_f.html

Van Haneghan, J.P., & Stofflett, R.T. (1995). Implementing problem solving technology into classrooms: Four case studies of teachers. *Journal of Technology and Teacher Education, 3*(1), 57–80.

Wetzel, K. (1993). Models for achieving computer competencies in preservice education. *Journal of Computing in Teacher Education, 9*(4), 4–6.

Willis, J. (1992). Technology diffusion in the "soft disciplines": Using social technology to support information technology. *Computer in the Schools, 9*(1), 81–105.