Gess-Newsome, J., Blocher, M., Clark, J., Menasco, J., & Willis, E. (2003). Technology infused professional development: A framework for development and analysis. *Contemporary Issues in Technology and Teacher Education, 3*(3), 324-340.

Technology Infused Professional Development: A Framework for Development and Analysis

Julie Gess-Newsome, J. Michael Blocher, Joëlle Clark, Jackie Menasco, and Elizabeth M. Willis
Northern Arizona University

*****

No one is less ready for tomorrow than the person who holds the most rigid beliefs about what tomorrow will contain.

Watts Wacker

*****

The world has changed in 30 years, and the changes that will occur in the next 30 years are sure to exceed our wildest expectations. But some issues in education are perennial, even while they take on the flavor of their social and historical context. Bork (2003), in his article "The Dilemma of Teacher Training," posed one such perennial issue — how to best prepare inservice teachers for changes within the educational field. He also proposed a potential solution — interactive computer tutorials that can be accessed anytime, anywhere. Although we, too, are optimistic about the potential of computing technology in education, perhaps the time is right to stop and look again at the research on learning and professional development of teachers.

Sputnik was a turning point in the world of science and education, spurring advances in curriculum, as well as sparking an era of research in education (DeBoer, 1991). Along with the creation of science curricula designed to help students understand the structure of the disciplines and the nature of scientific knowledge production, researchers began to explore the cognition of learning (National Research Council [NRC], 2000). Paralleling the large-scale teacher professional development efforts related to this new curriculum, researchers sought to identify the factors related to the successes and challenges of such efforts. This research resulted in a renewed respect for the knowledge and beliefs that teachers bring to the practice of teaching, and provided evidence to challenge past professional development practices and suggest new ones (Hall & Hord, 2001; Loucks-Horsley, Hewson, Love, & Stiles, 1998; NRC, 2000).

Our arguments in this article are based on the research surrounding the nature of expertise, how people learn, and forms of effective professional development. Developed from the literature that synthesizes the research in these fields, we will overlay current conceptions of learning and teaching onto the context of computing technology. We will then offer definitions and examples of professional development models based on computing technology, an analysis of the type of knowledge produced and the model's correspondence with research on effective learning and professional development, and an analysis of cost. We conclude the article with a call for a research base, similar to that developed for student and teacher learning, that will examine the impacts of technology-infused professional development models as they relate to teacher learning and student outcomes.

*****

In times of change, it is the learners who will inherit the earth while the learned will find themselves beautifully equipped for a world that no longer exists.

Anonymous

*****

Nature of Expertise

The book, *How People Learn* (NRC, 2000), provides a comprehensive synthesis of the research related to learning and the development of expertise. We begin our argument with the premise that teaching is a professional activity with a professional knowledge base. That knowledge base consists of at least three major domains: knowledge of the content, knowledge of the learner, and knowledge of the best ways and means to help students learn, often called pedagogical content knowledge (Shulman, 1986). Teachers enter the profession as novices in many of these areas and gain expertise with time, experience, and purposeful effort. Working from this premise, we assert that the goal of teacher professional development is to help teachers become experts in each of these domains so that they may most effectively impact student learning.

But what is expertise? The research recognizes several characteristics of expert knowledge (NRC, 2000). First, expert knowledge is *deep and developed over time.* Human beings are in a constant effort to make sense of the world around them. The more experiences we have, the more we know; and what we know is related to where and how we learn, making knowledge and its application *contextually bound*. But knowing facts, while important, is not the basis of expert knowledge. Expert knowledge is *organized and connected to big ideas*. Novices, as they are exposed to new ideas, initially see each idea having equal stature and importance. As expertise develops, one sorts ideas into categories and hierarchies where conceptual knowledge is built and differentiated through experience, reflection, and use.

This framework serves two purposes. First, it provides the expert *easy access* to knowledge, allowing it to be easily and flexibly applied to new situations. Second, the framework *facilitates future learning and application.* New ideas are examined against the framework, allowing for the addition of those that fit, or holding in abeyance others that need consideration prior to rejection or accommodation through reorganization of the framework. The context in which we learn information helps determine other situations in which we are most likely to apply that knowledge.

*****

If we don't change the direction we are going, we're likely to end up where we are heading.

Chinese proverb

*****

Contexts That Facilitate Learning

If teachers are viewed as needing expert knowledge, and professional development is viewed as one means of supporting the construction of that knowledge, then understanding the nature and characteristics of expertise provides us with a metric for our goals. Understanding how people learn, then, should inform the process by which we support learners, both teachers and students, in moving toward that goal.

Again, the research in learning has much to offer (NRC, 2000). Human beings are social as well as sense-making creatures, and research supports the notion that *learning is both an active and a social process*. In order to learn, one must make the decision to engage deliberately with an idea. Engagement with an idea is the first step in considering its fit in our existing structure of knowledge and includes not only interacting with an idea, but the process and struggle of learning, a process that is more motivating in social contexts. Engagement can come in the form of a new experience, an opportunity to inquire, or through a direct challenge to what we know.

In some cases, change is as simple as adding a new idea to our current structure. But in other cases, change is difficult. Our current knowledge can both facilitate and restrict our learning. When ideas come in conflict with what we know, we have to remove previous conceptions and the ideas linked to that conception and replace it with new knowledge. In other cases, we find that our entire framework is no longer adequate; forcing a complete overhaul while a new framework is built. To withstand this level of disequilibrium, we need continued social and cognitive support.

Having knowledge in and of itself is not sufficient to constitute expertise. The knowledge must be able to be applied to new situations, and *learning does not transfer easily to new situations*, especially since knowledge (and expertise) is contextually bound. So how can we challenge the chains of context? Learning something in multiple contexts and then looking for similarities of use across contexts helps to define appropriate applications and enhances knowledge transfer. This process is aided by the verbalization of one's thinking and consideration of challenges to that thinking.

Challenges to thinking, then, can be both external and internal. Other learners or the learning context can provide external challenges. Internal challenges can be created and *learning is facilitated when actively monitored*. This process, called metacognition, occurs when individuals recognize their learning goals, compare their goals to current knowledge levels, and then, through feedback, determine if the learning trajectory is on target or needs modification.

*****

We must become the change we want to see.

Mahatma Gandhi

*****

Principles of Effective Professional Development

The professional development efforts of the 60s and 70s were not a failure, but a learning opportunity. Many teachers participated in these programs and many returned to their classrooms as more knowledgeable and expert teachers. The measure of success, however, was not what teachers knew and were able to apply to the classroom, but whether the teachers could take the curriculum projects to which they were introduced and faithfully reproduce them in their classrooms (DeBoer, 1991). Using that measure, the post-Sputnik reforms were a failure. Why? The developers forgot that teachers were active, social, creative, thinking human beings who possessed previously formed professional ideals and successful teaching practices. Instead of simply reproducing the curriculum projects to which they were exposed, the teachers actively engaged with the materials, using ideas and activities that fit their current practices, molding and adapting others, and discarding lessons that were outside their conceptions of good teaching or appropriate goals for student learning (Hart & Robottom, 1990).

The problem of the professional development efforts of the 60s and 70s, then, were not based on the number of teachers needing professional development, but in ignoring teachers' views of effective teaching and learning, making classroom implementation from these experiences unpredictable.

From the analysis of this experience, the field of professional development has expanded its research base and advocated forms of professional development that are sensitive to teachers' incoming conceptions. A multitude of websites exist that explicate this new knowledge, including how these ideas about professional development intersect with technological applications. For example, the Eisenhower National Clearinghouse, maintains a comprehensive collection of curriculum and professional development materials and resources in mathematics and science. (*Editor's note*: The URL for this site and others are located in the Resources section at the end of this article.)

The National Staff Development Council (NSDC) is an international network of educators committed to improving teaching and learning by providing high quality professional development opportunities. The U.S. Department of Education Office of Educational Technology supports the national technology plan and promotes the use of technology for educational purposes. The North Central Regional Educational Laboratory offers a site that assists in planning professional development in technology. Apple Learning Interchange offers an online location where educators are encouraged to discuss issues surrounding effective instructional technology and share successful teaching strategies using a variety of media; and the George Lucas Educational Foundation collects and publicizes innovative instructional technology practices.

The first advance in professional development was to remove the idea of teacher "training." Teacher training defines teaching as a technical act and a skill-based activity that uses the following logic: if teachers are "trained" in the basic techniques of the curriculum, teaching performance will follow. The experiences of the 60s and 70s provide evidence that this is not the case. The notion of training has been replaced with that of teacher preparation and development. This concept recognizes teachers as professional, responsive, and in constant mediation between their knowledge of content, instruction and the needs of their students. The idea of teachers as operating from a professional knowledge base is widely accepted in the field today and explicitly acknowledged in documents such as the *National Science Education Standards* (NRC, 1996).

So what have we learned about teacher professional development? Drawing across the works of Loucks-Horsley et al. (1998), Gess-Newsome (2001), and Hall and Hord (2001), five general principles of effective professional development can be derived. First, professional development must be grounded in the context of a teacher's classroom. This principle is again based on the idea that learning is contextually bound and difficult to transfer. As teachers learn about teaching in the context of their classroom, the application of knowledge is clear and the motivation to learn is high.

Second, professional development must be developmentally appropriate. No two teachers are the same in their knowledge of content, instruction, and students, or in their experience in applying that knowledge to the classroom. Teachers must be supported at their current position on the journey from novice to expert. Professional development must start with the teacher and build on her/his current concept of teaching and learning and his/her goals and needs.

Third, professional development takes time. The advantage of thinking of teaching as a skill is that training can happen quickly, often in the matter of weeks. But when teaching is recognized as a profession with a goal of developing expert knowledge, it becomes understandable why achieving professional development goals often takes 3 to 5 years of sustained effort to significantly impact classroom instruction (Hall & Hord, 2001).

Fourth, professional development must contain the elements that promote learning. As noted earlier in this paper, these elements include an active and social environment that promotes change, transfer, and metacognition. Of particular importance is the role of collaboration in professional development. In nearly all studies of professional growth and change in classroom teaching, the presence of other colleagues who are attempting to do the same is the most consistent predictor of success (Becker, 1994; Holland, 2001; Hunter, 2001; Windschitl & Sahl, 2002).

Finally, professional development must allow teachers to take charge of their own professional growth. Teachers are professionals, not skilled laborers. Like all learners, teachers will only be impacted by those ideas in which they deliberately chooseto engage. Teachers must be afforded the respect to set their own course of development and be encouraged to actively monitor their own progress.

Based on this literature, it should be clear that teacher professional development is a process and not an event (Hall & Hord, 2001). The challenge to professional development is not so much the number of teachers that need to be impacted but (a) the commitment of time for sustained interaction with teachers while they examine their knowledge and beliefs, (b) the presentation of new ideas or experiences that challenge those current conceptions, (c) and the support needed to help teachers change their thinking about teaching and learning and put into place instructional practices that mirror those new beliefs.

The challenge is finding ways to create a pedagogical paradigm shift, leading teachers from viewing learning as passive to active, and shifting instructional strategies from the didactic delivery of information to creating a context that we know supports learning, including an active and social environment that promotes change, transfer, and metacognition. The challenge for those of us concerned with professional development is to make the same shift in our thinking about teachers as we hope teachers will make about their students.

*****

Efficiency is doing the thing right. Effectiveness is doing the right thing.

Peter F. Drucker

*****

Professional Development Facilitated Through Computing Technologies

Can technology assist us in the development of teacher knowledge? Absolutely. But with the infusion of technology, we must carefully examine the kind of knowledge produced, the ability of the technology to support best practices that facilitate learning, and the associated costs. In the following sections, we have highlighted a few examples of what the infusion of technology into teacher professional development may look like and how each model meets the criteria set forth in this article.

Face-to-Face Instruction With Technological Support

Definition and examples. Face to face instruction, by its nature, implies that instructors and students (teachers) are in the same place at the same time, engaged in the same content. The length and nature of the interaction, as well as the use of technology to support this instruction, can vary along a continuum. Contact time may move from one-shot, short-term workshops, through a sequenced series of interactions across a school year, to intensive and extended interaction in courses taken in isolation or that contribute to graduate or certificate programs. Each of these formats currently exists and has been examined for the strengths and limitations that they bring to the learning environment. None of these formats dictate the nature of the content involved, the interaction of the participants, or the role of technology.

Based on the familiar format, one might easily envision technology infusion that supports more didactic views of instruction: delivery of instructor prepared lectures via electronic slideshows, web-based access to written materials and resources, and Internet searches for supporting literature or instructional approaches. Indeed, this type of instruction could be described as an electronic replication of the lecture, where learners may click on a link to open a page, but may not read or understand it. While at times direct instruction has its place, it is not the v ision of technological infusion that has the most power to influence professional development.

The use of technology, however, does not have to be limited to these authority-based modes of teaching. Computer tools can offer learners opportunities to construct personally meaningful conceptions of teaching, as well as create products that reflect those conceptions (Bruckman & Resnick, 1996). Effective professional development,

regardless of how it is delivered, needs to go beyond learning new materials and skills. It must change classroom instruction in order to have an impact on student learning (NSDC, 2001.

Professional development utilizing technology should involve learning content in context and modeling pedagogically appropriate methods. This may include initial face-to-face professional development to learn new software applications and to develop shared understanding of goals for student learning. For example, a professional development project in Clark County, Nevada, involves a group of fourth-grade teachers convening to develop lesson plans for a new social studies unit. In order to accomplish this task, teachers initially met face-to-face to learn how to participate in online conferencing and to enhance their common understanding of the state's social studies standards in order to develop criteria for model lessons. The professional development also included attention to the development of group norms for continued work, which takes place through online conferencing.

In a scenario we have created that expands on this idea, we envision a graduate level course in standards-based curriculum and instruction in which teachers examine their own classroom instruction in light of desired learning outcomes. Using a problem-based learning approach (Woods, 1985), "Ms. Cheng," an elementary teacher in the course, is challenged to define the learning outcomes that she has for her students and create a curriculum framework that explicates and incorporates her goals. To organize her ideas, Ms. Cheng uses Inspiration (2003), a software package used to create concept maps.

Working in a team with three other upper-level elementary teachers, Ms. Cheng presents her concept map of learning outcomes, discusses how these outcomes are similar and different from those that she is currently able to achieve, and describes potential strategies to translate her desired outcomes into appropriate learning activities. The other teachers in Ms. Cheng's team help her examine the alignment of her stated goals and proposed instructional strategies, commenting where they see correspondence and challenging her to justify contradictions or to reexamine her thinking.

Following this refinement phase of the philosophy-to-teaching/learning alignment, Ms. Cheng decides to create and implement a social studies unit about Nevada history. In this unit, she wants students to work in small groups to examine the influence of transportation technologies on settlement patterns in the west, determine the characteristics of the individuals who had access to the various forms of transportation, and to translate those understandings to the socio-economic, racial, cultural, and linguistic traditions that exist across the state.

She uses technology first as a research mechanism to further her understandings about transportation technologies and gathers resources for herself and her students. She organizes this information into instructional goals and activities and through desktop publishing and presentation software assembles the materials for review by her team and for later use in her classroom with her students. Through combinations of electronic and face-to-face interaction, Ms. Cheng shares her ideas with her team and continues to refine her ideas.

Three weeks later, Ms. Cheng is ready to implement her unit. Her students are engaged in activities similar to the ones Ms. Cheng employed to design the unit: seeking resources on the web, developing themes and ideas using Inspiration, determining topics for small group work, and producing final group reports using Microsoft PowerPoint®. Through these presentations and a class concept map, Ms. Cheng's students assess their growing understanding of the topic. Later, Ms. Cheng and her elementary team in her graduate

course examine the PowerPoint presentations, video clips of the class, and the final class concept map for evidence of meeting the desired learning outcomes. Suggestions are made for future modifications of the unit and then the unit, in a refined format, is shared on CD ROM with the other teachers in the group for future use.

Type of Knowledge Produced and Correspondence With Research on Effective Professional Development

Face-to-face interaction implies a context for learning, not the content of learning. As such, it is difficult to characterize universally the type of knowledge an individual will take away from such an experience, especially as it relates to technology. Teaching can be reduced to a technical act reinforced by technology, or it can promote the professionalization of teaching by supporting reflective consideration of incoming beliefs and conceptions while offering new learning opportunities.

In our scenario, the professional development was supported both by face-to-face interaction and technology. The course required the teachers to reflect on their beliefs about teaching and learning; opened opportunities to challenge personal beliefs, the beliefs held by others, and the correspondence of beliefs to instructional practices; provided a context of support and collaboration with other teachers; and held student learning as the ultimate measure of success. In this scenario, both teachers and students were supported by technology to expand and organize their thinking, create meaningful products, and participate in a social learning community.

Face-to-face interaction takes time to plan and implement. Integrating technology into such contexts further increases planning time but may help extend learning opportunities beyond the temporal and spatial limits of the physical classroom. Short-term workshops have been consistently shown to be of limited effectiveness in changing teacher knowledge, beliefs, or classroom practices (Loucks-Horsley et al., 1998). Unless learning opportunities are extended and linked to the experiences of classroom teaching, learning outcomes will continue to be uneven. Technology provides a tool to make such extensions possible. As noted by the NSDC (2001),

Perhaps the best way to take advantage of the opportunities available through technology-mediated professional learning is to integrate e-learning into a balanced professional development program that combines formal face-to-face learning experiences optimally followed by online and one-on-one support, "just in time" training and development, and collaborative work on those tasks that most directly influence the quality of teaching and learning (Doubler et al., 2003). With these components built into a results-driven, standards-based, and job-embedded staff development program, the impact will be significant. (p. 21)

Cost

Development = medium. Delivery = high. Management = low.

Online Interactions

Definition and Examples

In the study of the integration of computing technology into distance educational learning environments, four types of interactions have been identified as desirable: learner-

computer, learner-instructor, learner-content, and learner-learner interactions (Hilliman, Willis, & Gunawardena, 1994; Moore, 1989). We would like to use these four forms of interaction to consider the impact of interactive tutorial systems, as well as other forms of online interaction in the pursuit of professional development.

Learner-computer interactions. Interactive learning units, as described by Bork (2003), act as an example of learner-computer interactions. In this instance, the student interacts with the computer in order to gain knowledge; the computer interacts with the student to determine next steps in pedagogical sequencing. In Bork's analysis, this form of interaction would engage more learners more often at a variety of cognitive levels. While such use of technology for learning may enhance communication, data retrieval, and research skills, it is only one of the four desired forms of interaction to the exclusion of others.

Learner-instructor interaction. Traditional distance learning environments relied heavily on learner-instructor interaction. In these cases, students and their instructors corresponded electronically on assignments and in conversations about the content. If used in isolation, these courses closely resemble correspondence courses. Although these interactions should not be removed from more robust distance learning environments, they are also limited in the delivery of varied forms of interaction.

Today, many online professional development programs continue to utilize multimedia technology to deliver instruction in traditional formats. In contrast, several tools are currently available that act more as a mechanism with which experts can provide scaffolds and support for the learners. Tools such as LiveText (2003), FolioLive (2003), and TaskStream (2003) provide a venue for teacher mentoring, standards management, electronic portfolios, and portfolio assessment that support professional development, whether it is conducted face to face or at a distance. These tools support an expert-novice mentorship relationship, in which the learning is contextually bound within the learners' educational environment.

Learner-content interaction. Much as in the interactive tutorial programs promoted by Bork (2003), most online professional development today is aimed at improving teachers' content knowledge through mechanisms that may or may not involve other forms of interaction. The PBS TeacherLine offers professional development modules to improve teachers' content understanding in mathematics and technology integration. The Jason Project™utilizes online sources to deepen science content knowledge, as well as suggesting classroom applications. Professional organizations such as the National Science Teachers Association are offering online professional development. By visiting the NSTA Institute, teachers are able to participate in coursework that includes concepts of modern biology, chemical ecology, principals of chemical biology, and modern molecular genetics.

Learner-learner interaction. Of all forms of interaction, the interaction with other learners has been repeatedly shown to be the most effective in changing teachers' classroom practice. In these programs, interactions require learners to interact with one another through peer discussions, team building, and collaborations on joint projects. As learners interact in this fashion, they interact with the content to provide a context-rich learning environment. TAPPED IN™ is a virtual place of work where educators worldwide can participate in professional development activities offered by education organizations, lead their own online activities, or expand their group of colleagues by participating in community-wide events. In addition to TAPPED IN, mentoring tools (like LiveText, etc.) also provide communication systems for learner-learner interaction.

Type of Knowledge Produced and Correspondence With Research on Effective Professional Development

Through online interactions, teachers can be honored for their incoming knowledge and skills while being challenged to increase their learning through social interaction with others. Indeed, as learners engage in distance learning environments, they may suffer from a lack of social presence without responsive interaction (Tu, 2002). It is through human interaction in online learning environments (i.e., learner-learner and learner-instructor interaction) that learners develop a community in which the members construct knowledge with others.

In professional development settings where electronic communication tools/systems are utilized, the development of a community of learners promotes learning. The computer is simply the tool or conduit transmitting the human interaction. As a result, professional development through online interactions helps span the constraints of time and space and offer professional learning opportunities to large numbers of teachers, but not without a high degree of facilitated interaction, which increases the cost of delivery.

Cost

Development = high. Delivery = medium. Management = medium.

*****

Spoon-feeding in the long run teaches us nothing but the shape of the spoon.

E. M. Forster

*****

Tutorials

Definition and Examples

Bork (2003) characterized his vision of computer tutorials as stand-alone modules that are interactive, adaptive to the needs of the individual, provided in the learner's native language, and accessible by the learner any time, any place with no need for additional instructor support. The system would prompt the learner to respond, assess the nature of the learner's conceptual knowledge, probe for understanding or conceptual difficulties, and provide the needed next interaction to support learning and maintain motivation. Information on the learner would be stored for later use, such as module improvement or customization of the next module to meet student needs.

While the design and potential of interactive computer tutorials is impressive, after 34 years of development, no examples were offered for examination. In addition, research results were not provided that indicate adequate learning through such a delivery system. In contrast, research does exist to show that when computers are used for higher level learning activities, such as simulations, development of models, or data analysis, students in these classes score higher on science achievement measures than do students in comparable classrooms (National Center for Education Statistics, 2000).

Type of Knowledge Produced and Correspondence With Research on Effective Professional Development

In the absence of examples, one can envision the types of knowledge for which tutorials would be effective. In particular, skill development and the delivery of factual content would be particularly effective through this deliverysystem. But is declarative and procedural knowledge the only outcome we seek for teachers or students?

Interactive tutorial systems have the potential advantages of rapid feedback and efficient delivery of instruction. Such systems, however, are less likely to be able to build conceptual knowledge or assist in application of newly acquired content to the types of constructivist teaching we desire, based on the context of the learning. Tutorials remove the social construction of knowledge with others (except the computer programmer) and may limit motivation or application. Tutorial systems also reinforce the idea that learning is something that is done *to* versus done *by* the individual, creating a reliance on the program to provide knowledge and analyze learning strengths and weaknesses. Tutorial systems are based on the antiquated assumption that didactic instruction, regardless of delivery mechanism, is sufficient to develop expert knowledge.

Learning in the timeframe indicated by Bork (2003) — in some cases, within 1 hour — also seems unrealistic, provided that the level of learning is anything above recall. We believe that the research evidence included in this article refutes the promise of conceptual learning through this mechanism and on the described time scale. Though tutorials certainly have their uses, as an exclusive form of professional development, they simply are not responsive enough to teachers' learning needs. As we are reminded,

In any professional development provided either face-to-face or electronically, the emphasis must move beyond educator's acquisition of knowledge and skills and to implementation in the school and the classroom for the purpose of improving student learning. (NSDC, 2001, p. 4)

Cost

Development = high. Delivery = low. Management = low.

Web Access to Digital Archives

Definition and Examples

Digital technologies offer unprecedented opportunities to capture information that can assist in the professional development of teachers. Rich databases are being developed or proposed that can be searched and organized in multiple ways, allowing the learner to construct questions, access data, and engage in the analysis and construction of new learning to match their needs. Three forms of digital archives may significantly influence teachers: authentic data and documents, research findings, and professional knowledge.

In the past, teaching often consisted of passing down to students those patterns and interpretations of data that could be synthesized by experts from the existing data. This is particularly true in the sciences and social sciences. History was created by historians and then reinterpreted into textbooks. Science was presented as a distilled set of ideas based on the thinking of others. Allowing students to engage in all but the most rudimentary opportunities to examine real data presented problems of access and opportunity.

With the advent of digital archives, however, these problems are disappearing. Teachers and students can now access authentic historical documents, including maps, journals, news accounts, personal letters, public financial documents, and court records, to reconstruct history. For example, the University of Virginia has developed digital archives of primary sources to be used by students to conduct historical research and reconstruct historic events. Within the Virginia Center for Digital History, projects include the Valley of the Shadow Project: Two Communities in the American Civil War, a multimedia archive that follows two communities, one northern and one southern, through the experience of the American Civil War; Virtual Jamestown; Race and Place: African American Community History; Presidential Recordings Project; and Dolley Madison Project (see Mason et al., 2000, for more details).

The GLOBE program is a worldwide web-based scientific and educational program that involves student collection, manipulation, and interpretation of data. GLOBE is designed to have students carry out a series of investigations about their local school environments, gather and submit those data so that students worldwide, and research scientists can study how the earth functions as a global system. The data are entered via a password-protected website, which can then be viewed and investigated through a variety of indicators, ranging from specific scientific measurements to longitude and latitude. With these data, students are encouraged to conduct deeper inquiries about their local environments. Such opportunities are changing the landscape of student learning and reinforcing the notion of teachers (and technology) as facilitators of learning, as opposed to the deliverers of information.

Formal research on topics of educational importance also offers an opportunity for professional development. Recognizing the abundance of research findings, the international Campbell Collaboration created a website in 2000 to provide an accessible electronic library of research in the social, behavioral, and educational fields. Organized as a searchable database, teachers and researchers can enter key terms and locate research that can be analyzed and synthesized to answer questions of educational importance. A similar database is being called for as part of the No Child Left Behind Act, providing teachers and policy makers with scientifically based research on which to frame educational decisions. Use of such resources can act as a powerful platform for the expansion of teacher learning and can help educational researchers span the gap between the conduct of research and its application to decision making at the classroom, school, and policy levels.

While the collection and organization of the formal research literature represents a tremendous tool, few teachers find this knowledge directly applicable to their classroom practice. Through the act of teaching, teachers develop their own knowledge and expertise. This professional knowledge, often defined as craft knowledge, speaks to teachers in a way that archived research knowledge does not. Craft knowledge is best captured as classroom examples of practice that can be related to and illustrative of educational theory.

Hiebert, Gallimore, and Stigler (2002) struggled with the challenge of envisioning a mechanism to capture and capitalize on the power of professional knowledge. In doing so, they recognized that this knowledge must be public, storable, and sharable and must provide a mechanism for verification and improvement. This deliberation resulted in a proposal for a multimedia digital archive that could store videoclips of teaching, examples of lesson plans and student work, teacher reflections, and commentaries by teachers and researchers. Organized around curricular topics or educational issues, the archive could act as a repository of data about teaching, a stimulus for learning about teaching, a source

of expert reflection, and a vehicle to connect practice to theory by teachers and researchers.

Type of Knowledge Produced and Correspondence With Research on Effective Professional Development

In an attempt to define what a professional knowledge base for teaching may look like, Hiebert et al. (2002) proposed that professional knowledge must possess the following features: linked with practice; detailed, concrete and specific; and integrated. It should be obvious that many of these features mirror both the characteristics of expertise and best practices in professional development. Digital databases provide teachers with an opportunity to structure their own learning, capture their own knowledge, and contribute to the knowledge of o thers. Digital databases can remove constraints of time and space, while offering opportunities for individual and collaborative learning from authentic documents and contexts. Learning in this manner honors the knowledge that teachers bring to their education, while challenging them to deepen their understandings through application to new contexts. As in other instances noted here, in order to capitalize on the opportunities afforded by digital archives, teachers must be willing to embrace the idea of learning as an active, social, and constructive process, both for themselves and their students.

Cost

Development = high. Delivery = low. Management = low.

*****

The future is literally in our hands to mold as we like. But we cannot wait until tomorrow. Tomorrow is now.

Eleanor Roosevelt

*****

Conclusions

What do teachers need to know and be able to do in order to be effective in the classroom? How can professional development assist teachers in gaining this knowledge?

Looking at educational pedagogy from an elementary perspective, the way the first question is answered will determine how the second is approached. Knowledge can be viewed as existing outside of the learner, reified in fundamental truths, and teaching is thus a process of mastering this knowledge through direct instruction. Learning is measured by assessing students' ability to acquire and repeat factual information. Tutorials, as well as other didactic modes of instruction (regardless of format), can act as an effective means of increasing such a knowledge base at a relatively low cost to a large population of teachers.

Knowledge can also be envisioned as something beyond a set of facts, concepts, skills, or laws to be memorized. In this case, knowledge is viewed as more complex, requiring an understanding of cause and effect and the use of critical thinking skills. Knowledge does

not exist independently of the knower, but is constructed by the knower based on previous experience, opportunity to learn, and knowledge use. In order to build such a knowledge base, learning must be active and social, and recognize the need for change, transfer, and metacognition. For teachers, learning must be grounded in the classroom and developmentally appropriate, and must recognize the time and effort needed for true understanding to develop.

Teachers, as well as professional developers, often find themselves using instructional strategies that could fall into either conception of learning; sometimes transmitting ideas, other times helping students construct new ideas. The art and craft of becoming a master teacher, then, may be exemplified by the purposeful selection of the instructional strategy that will best serve the learner, his or her learning strengths and background knowledge, the learning environment, and the content (Blocher, Sujo de Montes, Willis, & Tucker, in press). The goal of professional development, then, is to help teachers master the knowledge base of teaching and to make deliberate instructional decisions that will result in student learning.

To this complexity is now added the challenge of integrating information technologies into professional development. The infusion of technology cannot act as a panacea for the challenges of professional development. Technology is simply a tool that can enable a learner to interact with content and, perhaps, other learners. But how we use this tool is important. Technology can either reinforce the transmission of knowledge or liberate learning opportunities and knowledge construction. Perhaps more than a tool, technology may act as a mirror. The way we use technology in professional development, and teaching of any type, speaks volumes to our views of knowledge, expertise, teaching, learning, and the role of teachers and students in schools. As stated by the National Staff Development Council (2001),

E-learning has the potential to expand and enrich learning opportunities for educators by employing alternative processes not available in the face-to-face arena. However, in order to be as effective as face-to-face development in deepening understanding and improving performance of both educators and their students, e-learning for educators will need to meet the same high standards for face-to-face professional learning. (p. 4)

We would like to return this article to the place we began. Professional development is a perennial challenge in education. With the advent of technology, we have added to our arsenal of alternative tools to help us in meeting this challenge. However, in addition to our increased access to technological tools, we have a research base in teaching, learning, expertise, and professional development that can help us examine how to best capitalize on technology to improve student learning. Our new challenge is to assess carefully the impacts of the infusion of technology into teacher professional development through research, document those results, and use them to inform future efforts so that we may positively impact teacher and student learning.

References

Becker, H.J. (1994). How exemplary computer-using teachers differ from other teachers: Implications for realizing the potential of computers in schools. *Journal of Research in Computing in Education, 26*(3), 291-321.

Bork, A. (2003). The dilemma of teacher training. *Contemporary Issues in Technology and Teacher Education, 3* (2). Retrieved October 1, 2003, from http://www.citejournal.org/vol3/iss3/general/article1.cfm

Blocher, J. M., Echols, J., Sujo de Montes, L., Willis, E.M., Tucker, G. (In press). Shifting from instruction to construction: A personal meaningful experience. *Action in Teacher Education*.

Bruckman, A., & Resnick, M. (1995). The MediaMOO Project: Constructionism and Professional Community. *Convergence, 1*(1), 94-109.

DeBoer, G.E. (1991). *A history of ideas in science education: Implications for practice.* New York: Teachers College Press.

Doubler, S., Laferriere, T., Lamon, M., Rose, R., Jay, M., Hass, N., Polin, L., & Schlager, M. (2003). *The next generation of teacher online learning: A developmental continuum*. Retrieved March 25, 2003, http://www.cilt.org/resources/online_Learning.html

Gess-Newsome, J. (2001). The professional development of science teachers for science education reform: A review of the research. In J. Rhoton, & P. Bowers (Eds.), *Professional development: Planning and design* (pp. 91-100). Reston, VA: NSTA Press.

FolioLive.Com. (2003). [Computer software]. Columbus, OH: McGraw-Hill Companies.

Hall, G. E., & Hord, S.M. (2001). *Implementing change: Patterns, principles, and potholes.* Boston: Allyn and Bacon.

Hart, E.P., & Robottom, I.M. (1990). The science-technology-society movement in science education: A critique of the reform process. *Journal of Research in Science Teaching, 27*(6), 575-588.

Hiebert, J., Gallimore, R., & Stigler, J.W. (2002). A knowledge base for the teaching profession: what would it look like and how can we get one? *Educational Researcher, 31*(5), 3-16.

Hillman, D. C., Willis, D. J., & Gunawardena, C. (1994). Learner-interface interaction in distance education: An extension of contemporary models and strategies for practitioners. *The American Journal of Distance Education, 8*(2), 30-42.

Holland, P.E. (2001). Professional development in technology: Catalyst for school reform. *Journal of Technology and Teacher Education, 9*(2), 245-267.

Hunter, B. (2001). Against the odds: Professional development and innovation under less-than-ideal conditions. *Journal of Technology and Teacher Education, 9*(4), 473-496.

Inspiration Software. (2003). [Computer software]. Portland, OR: Inspiration Software Inc.

LiveText.Com. (2003). [Computer software]. Chicago, IL: LiveText Inc.

Loucks-Horsley, S., Hewson, P.W., Love, N., & Stiles, K.E. (1998). *Designing professional development for teachers of science and mathematics*. Thousand Oaks, CA: Corwin Press, Inc.

Mason, C., Berson, M., Diem, R., Hicks, D., Lee, J., & Dralle, T. (2000). Guidelines for using technology to prepare social studies teachers. *Contemporary Issues in Technology and Teacher Education* [Online serial], *1*(1). Retrieved March 25, 2003, from http://www.citejournal.org/vol1/iss1/currentissues/socialstudies/article1.htm

Moore, M. G. (1989). Three types of interaction. *The American Journal of Distance Education, 3*(2), 1-6.

National Center for Education Statistics. (2000). The nation's report card: National assessment of educational progress, 2000 science. Retrieved March 25, 2003, from http://nces.ed.gov/nationsreportcard/science/results/teachcomputer.asp

National Research Council. (1996). *National science education standards*. Washington, DC: National Academy press.

National Research Council. (2000). *How people learn: Brain, mind, experience and school*. Washington, DC: National Academy Press.

National Staff Development Council. (2001). NSDC's standards for staff development, revised edition. Retrieved March 24, 2003, from http://www.nsdc.org/educatorindex.htm

Shulman, L.S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(1), 4-14.

Taskstream.Com. (2003). [Computer software]. New York: TaskStream.

Tu, C., (2002). The impacts of text-based CMC on online social presence. *Educational Journal of Online Interactive Learning, 1* (2).

Windschitl, M., & Sahl, K. (2002). Tracing teachers' use of technology in a laptop computer school: The interplay of teacher beliefs, social dynamics, and institutional culture. *American Educational Research Journal, 39*, 165-205.

Woods, D. R. (1985). What about problem-based learning? *Journal of College Science Teaching, 15*(1), 62-64.

Resources

Apple Learning Interchange - http://ali.apple.com/

Campbell Collaboration - http://campbell.gse.upenn.edu/

Clark County, Nevada, professional development project - http://www.nsdc.org/library/results/res9-01rich.html

Dolley Madison Project - http://moderntimes.vcdh.virginia.edu/madison/index.html

Eisenhower National Clearinghouse - http://www.enc.org/topics/edtech/

George Lucas Educational Foundation - http://glef.org

GLOBE program - www.globe.gov

Inspiration - http://www.inspiration.com

Jason Project™- http://www.jasonproject.org/jason_academy/jason_academy.htm

National Staff Development Council - http://www.nsdc.org/

North Central Regional Educational Laboratory - http://www.ncrel.org/tech/tpd/

NSTA Institute - http://institute.nsta.org/

Presidential Recordings Project - http://jefferson.village.virginia.edu/vcdh/kennedy/index.htm

Race and Place - http://www.vcdh.virginia.edu/afam/raceandplace/index.html

TAPPED IN™- http://www.tappedin.org

TeacherLine - http://teacherline.pbs.org/teacherline/

US Department of Education Office of Educational Technology - http://www.ed.gov/Technology/index.html

Valley of the Shadow Project - http://valley.vcdh.virginia.edu/

Virginia Center for Digital History - http://www.vcdh.virginia.edu/

Virtual Jamestown - http://jefferson.village.virginia.edu/vcdh/jamestown/

Contact Information:

Julie Gess-Newsome
Northern Arizona University
Julie.Gess-Newsome@nau.edu