Advancing Technology Education: The Role of Professional Development

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Susan Loucks-Horsley, internationally known for her educational contributions, died August 9, 2000 in Colorado Springs of injuries sustained in an accidental fall. At the time of her death, Susan was Associate Executive Director at the Biological Sciences Curriculum Study (BSCS) in Colorado Springs, CO, and a Senior Research Associate at WestEd in Tucson, AZ.

Beginning in 1998 Susan served on the Technology Education Advisory Board (TEAC). She contributed to ITEA through professional development and her advice on implementing the Standards for Technological Literacy. She will be greatly missed by her colleagues.

Release of the technological literacy standards will require the community to engage in professional development. Why? Because the release of technological literacy standards is only the first step in the journey of educational reform. If the standards are to be realized in curriculum, instruction, and assessment, then the communities directly involved in these activities will have to assume responsibility for seeing that changes are implemented. The most direct route in this portion of the journey is professional development.

by Rodger W. Bybee
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THE ROLE OF PROFESSIONAL DEVELOPMENT

Thompson and Zeuli (1997:1) succinctly state the essential role of professional development:

It is now widely accepted that, in order to realize recently proposed reforms in what is taught and how it is taught [as described in the standards document]…, teachers will have to unlearn much of what they believe, know, and know how to do (Ball, 1988) while also forming new beliefs, developing new knowledge, and mastering new skills. The proposed reforms constitute, if you will, a new curriculum for teacher learning. If they do not specify precisely what teachers should know and be able to do, they do outline it rather clearly and exemplify aspects of it with a nearly literary vividness.

Standards cannot directly change behavior or beliefs, but they can point the way by defining desirable goals, stimulating movement toward the goals, and reducing conflicts among the policies under which educators at each level labor. They can begin to create images of what different components of the educational system would look like were they to be aligned with the desired outcomes for students. Although some have argued that policies (including standards) might be viewed as an effort to teach those who must carry them out rather than solely as an effort to induce or

constrain them to behave differently (Cohen & Barnes, 1993), teaching students and adults requires far more than attending to policy statements. Professional development is a critical companion to, but not the same as, the implementation of the standards.

Professional development will provide the opportunities for technology teachers and other educators to learn what they need to know and be able to do as they assist students in achieving the technological literacy standards. Effective professional development, we believe, must pay attention to four needs. First, teachers need to learn about and develop skills related to technology; they need opportunities to deepen their content knowledge. Second, teachers need opportunities to learn about how to teach technology—to combine their content knowledge with what they know about learning and how to teach their particular content. Third, teachers need tools to help them continue their own learning, and the motivation to do so. In a field that is changing as rapidly as technology, teachers need to expect their knowledge and skills to become outdated quickly and they must know where and how to continue to learn. Finally, fragmentation plagues current learning opportunities for teachers: courses, workshops, and institutes are rarely coordinated or sustained over time so that teachers get both depth and breadth in what they need to know and be able to do. Long-term professional development *programs*, not just events, are required to support the kinds of changes required for the technological literacy standards to touch all students.

Our experiences with writing and supporting the implementation of the *National Science Education Standards* (NRC, 1996) and our work in professional development (Loucks-Horsley, Hewson, Love, & Stiles, 1998) suggest these four areas to guide the plans for professional development:

Learning about Technology, Learning to Teach Technology, Self Assessment and Continuous Improvement of Technology Teachers, and Comprehensive, Sustained Professional Development Programs.

LEARNING ABOUT TECHNOLOGY

Because the technological literacy standards call for students to acquire deep understanding of important, fundamental, technology concepts and processes, teachers need to know technology as deeply—in fact, more so. The standards call for teachers to assess their students' understanding of the designed world and help their students enhance those understandings through new and multiple, often concrete, experiences. Without their own understanding of the technology involved, teachers cannot do this—staying "one chapter ahead of the kids" may have been a survival skill in days past, but it will no longer suffice. One thinks of an analogy to science, namely the frequently-cited examples from the Harvard-Smithsonian "Private Universe" video series in which MIT and Harvard graduates are unable to explain why there are seasons and how a seed becomes a tree. These scenes suggest that if teachers do not understand the science involved in everyday occurrences, their students will learn no more than the graduates interviewed in the videos. Similarly, if technology teachers do not understand deeply the technology concepts they are trying to teach, one cannot expect their students to learn.

Research in several disciplines on how students learn best, and subsequently how they should be taught, is becoming richer as several lines of study converge. One line of study, the cognitive research and that of conceptual change, emphasizes the learner's active construction of new knowledge based on current knowledge,

rather than through straight and somewhat simple acquisition. This research underscores the tenacity of extant knowledge, which is difficult to replace by simply suggesting new ideas, and the importance of challenging current ideas and providing multiple opportunities to interact with phenomena (materials, events, representations) that replace or enhance those with new ideas based on scientific and technological principles (Guzzatti et al., 1993). This literature is joined by extensive studies of students' misconceptions about science and technology—particular concepts for which students at certain ages have their own personal and predictable explanations. To be sure, those explanations are often not scientifically or technologically correct (Driver et al., 1994). Finally, there are many studies of approaches to teaching and use of curriculum materials based on models for learning that draw on these lines of research (Anderson, 1998; Shymansky, Kyle, & Alport, 1983).

These lines of research support learning technology through activities that in many ways mirror that of designers and engineers seeking to solve problems or to produce new knowledge or products. One example of a professional development opportunity that does this is when high school teachers spend several weeks during the summer with laboratory engineers, working on their teams and participating in their ongoing research and development. As teachers work as partners to the engineers, they develop new design abilities, come to understand the process of technological problem solving, appreciate the dead ends and uncertainties of engineering, use new technologies, and examine the engineering and design literature. Teachers deepen their understanding of technology, build their design abilities and understandings, and do so through their participation in actual design problems.

To build their knowledge and skills in technology, elementary school teachers might attend a two-week summer institute and work with engineers and technology educators to develop and conduct investigations using a design-oriented approach. Typically limited in their technology background and lacking confidence in their abilities to teach technology, teacher participants would strengthen their understanding of technology content and how they could help their students learn it. One very important aim of this experience is for elementary school teachers to learn the difference between science and technology so they can illustrate these differences to their students through classroom activities.

LEARNING TO TEACH TECHNOLOGY

Knowing about technology is only one part of being able to teach it. As deep as their knowledge of technology often is, many individuals cannot teach expertly. This is because they do not have "pedagogical content knowledge," which is a special knowledge and set of abilities possessed by expert teachers. Shulman (1987) describes teachers with pedagogical content knowledge as knowing how students develop their understanding of a particular concept (e.g., systems), what they are able to understand, what they are apt to stumble over at certain stages of development, and through what examples, representations, and experiences they will learn best. In order to build their pedagogical content knowledge, teachers need to know technology. They also need to understand how students learn technology, what kinds of experiences facilitate their learning, and what learning environments foster the exploration and openness to new ideas that must accompany learning. A foundation for pedagogical content knowledge can be built through study

of the literature on learning and teaching, but it is only through practicing and reflecting on teaching practice that teaching expertise can be developed (Shulman, 1987).

Professional development is critical for helping teachers develop pedagogical content knowledge. A number of different strategies for professional development are currently being used and tested (Loucks-Horsley et al., 1998). Most promising are strategies that allow teachers to examine student learning and their own teaching practice, sometimes with the help of curriculum materials that they use with their students. One example is the strategy being used by many large-district, elementary school science reform initiatives, in which a set of curriculum materials is chosen and carefully implemented. Teachers attend a series of workshops spaced throughout the school year where they experience the science units as learners, reflect on the successes and problems encountered in the units they have already taught, receive in-class assistance through demonstrations and coaching, and have easy access to materials through a support system that delivers and replenishes them without extra work by the teachers. After mastering the "mechanics" of teaching the units, which usually takes the first year, professional development sessions guide teachers to collect and examine student work, determine what students understand, and learn how they as teachers can assist in students' conceptual development. Curriculum-based professional development can be particularly effective when teachers do not have the understanding of content they need in order to create their own curriculum (Ball, 1996; Russell, 1998).

SELF-ASSESSMENT AND CONTINUOUS IMPROVEMENT

Effective professional development helps teachers learn, and it also gives

them tools for further, often less formalized, learning. One strategy that does both is action research, in which teachers determine what questions they are most interested in asking about their students' learning and their own teaching, and pursue those questions by collecting and analyzing data and sharing their results. For example, teachers might conduct action research on how their students are learning a particular concept in technology and what they are struggling with; or how students' mathematics or science knowledge helps or hinders their technology learning; or any special problems or advantages students with limited English have in technology learning. While learning about technology and technology teaching, these teachers develop skills in observing, data analysis, and creating explanations for their observations. These tools can be used for self-assessment and improvement over time and for a variety of other purposes.

Another professional development strategy that provides teachers with tools for continuous improvement is coaching. There are numerous forms of coaching that can help teachers help each other learn, and each form has particular skills and procedures that optimize its effectiveness (Loucks-Horsley et al., 1998). For example, middle grade teachers are particularly concerned about encouraging girls and members of groups typically underrepresented in technology careers. Coaching programs can help teachers achieve this goal by focusing classroom observations on the amounts and kinds of attention that they give different students. This is eye-opening for many teachers who believe they provide their students with equal opportunities to learn, but in reality limit the amount of time different students have to participate (e.g., do they call on them a lot or a little?) and the level of demand they

put on students' thinking (e.g., do their questions ask students to recall facts or to analyze the risks and limitations of their proposed solutions?).

COMPREHENSIVE, SUSTAINED PROFESSIONAL DEVELOPMENT PROGRAMS

Increasingly, more professional developers are recognizing that teachers need opportunities to study the content and pedagogy they need to know over long periods of time, with coherence of content and context, and in a way that allows for regular application and reflection (Loucks-Horsley et al., 1998). Yet there are still many "menu-driven" offerings: catalogues from which teachers can select two- to six-hour workshops, and courses that have no connection to each other nor to the teachers' curriculum and their students. As consumers of professional development, technology teachers need to learn to demand more comprehensive, long-term opportunities to learn. Professional development providers (including teacher leaders, district administrators, higher education faculty, trainers and consultants external to school districts) in districts, universities, and other locations need to abandon their overwhelming emphasis on short-term workshops and institutes and design better opportunities to help teachers truly transform their practice.

Long-term professional development programs and initiatives are appearing at every level of the system. For example, in science education some districts offer teachers 100 hours of professional development that incorporates implementation of new instructional materials; universities offer masters programs that focus on integrated science and curriculum development; and professional networks offer teachers the opportunity to share teaching strategies and dilemmas and learn new programs designed to engage more students in learning a

subject. These examples could well apply to technology education.

CONCLUSION

Standards for technology education and professional development are critical companions. Professional development is needed for the technological literacy standards to move outside the very documents that contain them and eventually into the practice of every teacher and the learning of every student. Fortunately, professional development can provide the necessary learning opportunities for teachers and other educators and lead them to support the ambitious learning goals we hold for all students learning technology.

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