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Wicked Problems and Other Thoughts on Issues of Technology and Teacher Learning

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This telephone has too many shortcomings to be seriously considered as a means of communication. The device is inherently of no value to us.

An internal Western Union memo, 1876

I think there is a world market for maybe five computers.

IBM chairman Thomas Watson, 1943.

There is no reason anyone would want a computer in their home.

Ken Olson, founder, chairman and president of Digital Equipment Corporation, 1977.

Any sufficiently advanced technology is indistinguishable from magic.

Arthur C. Clarke (1963), English physicist and science fiction writer, p.

We've come a long way and at an incredible pace. What was magic less than a generation ago is now part of everyday life. Digital technologies are changing the way we live, work, and learn. Their potential to transform K-12 education motivated our decision to devote a theme issue of *Journal of Teacher Education* to the innovative uses of technology for teacher learning.¹ Although optimistic about the possibilities new technologies offer to support K-12 learners' achievement, teachers' productivity, effectiveness in classrooms, and teacher learning, we also recognize that teaching and learning with new technologies represents a "wicked problem" (Koehler & Mishra, 2008). Rittel and Webber (1973) characterized

wicked problems as problems that include a large number of complex variables—all of which are dynamic, contextually bound, and interdependent. The rapid growth of digital technologies, coupled with the complexity of classroom life, increases both the potential transformative power and the difficulty of problems associated with incorporating innovative technologies in teaching and teacher education. Our aim in organizing this theme issue was to explore these possibilities and complexities.

Our call for this issue invited "research manuscripts that address how these technologies inform teacher candidates' understanding of real classrooms and veteran teachers' professional development . . . that examine the unique opportunities and obstacles presented through these inventive uses of technology, or that provide evidence for their impact on teachers' learning and practice."

Perhaps it is not surprising that our understanding of what it takes to integrate technology effectively into teaching and teacher education has grown through the process of putting together the theme issue. We now have a sharper sense of the relationship between issues involved in using technology to support teacher learning and those that must be addressed to support the uses of technology to foster K-12 student learning. In the big picture, innovative teacher educators are creating technology-rich approaches that promote the development of tech-savvy teachers—teachers who regularly use digital

Authors' Note: We would like to thank our colleagues Susan Maunders and Karin Forssell for their critical reading of this article. As an editorial team, the editors write editorials collaboratively. To reflect the nature of this joint work, they rotate the order of authors with each journal issue.

technologies to guide their own learning, recognize the pedagogical potential of technology to help children and youth understand content, and know how to embed new technologies in their instructional practices. We recognize that the call for this theme issue did not invite articles examining how teachers learn to embed technology in their classroom practice to teach content in powerful ways.

The six articles in this issue tackle the role that new technologies—particularly video and online communities—play in learning to teach. Taken together, they examine the promise digital technologies hold to help teacher educators overcome persistent dilemmas encountered when designing scalable, sustainable programs to support teacher learning. The different approaches described in the articles illustrate why developing tech-savvy teachers is a “wicked problem” and why teacher education must be involved in understanding and managing the dilemmas associated with integrating technology into teacher education and K-12 classrooms.

In the remainder of this editorial, we contextualize the issue’s articles. We consider pedagogical affordances and constraints of digital technologies, uses of digital technology in teacher education and professional development, and the conceptualization of a new form of teacher knowledge related to integrating technology—technological pedagogical content knowledge (TPACK; Mishra & Koehler, 2006). Acknowledging the very limited knowledge base related to these topics, we also suggest potentially useful research directions.

Pedagogical Affordances and Constraints of Digital Technologies

Technology, in its broadest sense, is the knowledge, creation, and use of tools and techniques to control and adapt to our environment. This definition encompasses both analogue technologies such as the chalkboard, pencil, microscope, and overhead projector; as well as newer technologies such as the Internet, e-mail, online publications, and video games. In contrast to analogue technologies, which are well integrated into all levels of our education system, the educational potential of these newer digital technologies is only beginning to be realized.

As we explore ways to harness the potential of digital technology to improve teaching and learning, it is essential that we keep in mind that technologies are not neutral; particular technologies have specific affordances and constraints. Some of these are inherent in the technologies, whereas others are imposed by the contexts in which they are used (Koehler & Mishra, 2008). We first consider the inherent affordances.

Attributes of digital technologies that make them particularly appealing to educators include the following: the almost limitless capacity to store information; the ease of accessing, searching, and retrieving information from large databases; the ability to juxtapose multiple artifacts that capture the complexity of experience; and immunity from the constraints of time and place. These attributes offer the potential for education to reach large numbers of individuals, including those in relatively inaccessible places. Asynchronous interactive tools such as bulletin boards and threaded discussions enable students and teachers to participate in discussions “anytime, anyplace,” as well as easily archive these exchanges for later consideration. Some of the newer online learning environments provide a collection of digital tools that offer real-time participation in an educational event as well as easy access to resources such as the course syllabus, assignments, reading materials, and links to outside resources; communication through notice boards, chat rooms, and threaded discussions; and facilitation of course administration and record keeping. New tools create shared work spaces that allow individuals to collaborate in the analysis and development of artifacts and documents. And the possibilities of virtual worlds (e.g., Second Life, or imagine a World-of-Warcraft-like adaptation for teachers and teacher candidates) have yet to be tapped.

Newer digital technologies also share several properties that complicate their integration into educational settings and may become real constraints to their use. Foremost among these is their instability. This instability, a result of the rapid pace at which new technologies are developed and disseminated, creates numerous challenges for the educational community. It ensures that the knowledge required to use digital technologies is never fixed. Accordingly, teachers and teacher educators must continually keep up with the changing opportunities and demands created by new technologies.

To stay competitive, developers often distribute new technologies before they are fully tested; thus, many software programs are error prone and riddled with bugs. Innovations in hardware are too often unreliable (a fact to which most users of wireless devices can attest) and updated versions of software and hardware are frequently incompatible. As a result, the never-ending process of learning to use advanced information and digital technologies in teaching can be fraught with ambiguity and frustration (Koehler & Mishra, 2008).

The instability and unreliability of some innovations also challenges an institution’s financial and intellectual resources. Educational institutions have limited resources to maintain a technology infrastructure and to develop

individuals' capacity to use technology effectively. These limitations add to the complexity and potential aggravation of learning to teach with technology—to the wickedness of the problem. Therefore, it is crucial that investments in both the technologies and the preparation that supports their use be made wisely and efficiently so that they add value to the learning experience. Education can ill afford glitzy technology for the sake of glitz. To guide wise allocation of technology resources, research is needed to illuminate technology's impact on teacher learning, on classroom practice, and eventually on student learning.

As this discussion suggests, the unique features of digital technologies can create novel learning experiences, but inherent attributes of technology (instability, unreliability) and the ways in which institutional contexts allocate resources to technology integration also create barriers to realizing them. In the sections that follow, we consider these issues in the context of existing and potential uses of digital technologies to support teacher and student learning.

Uses of Digital Technologies in Teacher Education and Professional Development

Recent advances in digital technologies are having a strong impact on teacher education and professional development. Professional development programs attempting to “scale up,” for example, are increasingly turning to these contemporary, innovative technologies as a way to reach large numbers of individuals, potentially at costs lower than those associated with the physical presence of professional development (PD) facilitators (Goldman, 2005). These technologies also enable PD providers to draw on resources not available locally, offer “just-in-time” work-embedded support, and accommodate individual teachers' busy schedules.

The use of digital technologies to support teacher learning can take several forms. Perhaps most common are (a) video and digitized artifacts as a tool to provide a shared classroom experience in teacher education and professional development, (b) online social networks for educators, and (c) online professional development programs. Video has become increasingly popular as a tool in teacher education and professional development because of its unique ability to capture the richness and complexity of classrooms for later analysis. Video records can highlight aspects of classroom life that a teacher might not notice in the midst of a lesson. With the aid of external microphones, it is possible to record small-group interactions and teachers' conversations

with individual students that are not typically available to an observer in the classroom. Teacher educators can select video excerpts to address particular features of teaching and learning, and these excerpts can be used to focus individual and collaborative reflection and analysis. Articles in this issue by Santagata and Sherin and van Es explore the use of video in preservice teacher education and professional development, respectively. Rich and Hannafin provide a review of video annotation tools that serve to scaffold and structure teacher reflection on video. The article by Hatch and Grossman illustrates the potential of layering video with other artifacts of practice in a format they call “digital exhibitions” to support teacher learning.

Professional learning communities that use social networking software provide another, quite different, example of the innovative use of technology to support teacher learning. These online communities, or networks of communities such as Tapped In, draw on the rapidly expanding features of social networking technology to enable educators to work and learn together in synchronous and asynchronous discussion forums, with the purpose of sharing expertise and supporting practice. As Schlager and Fusco (2003) explained,

Tapped In has been quite successful in achieving its original goal of bringing together and forging new relationships among education practitioners, providers, and researchers from around the world on a daily basis. Thousands of different people log in each month to engage in activities that include course and workshop sessions, group meetings, and public discussions spanning a wide range of K-12 topics. (p. 204)

The article by Schlager and colleagues in this issue presents a preliminary analysis of data collected across professional learning communities in the Tapped In network and calls for the creation of a new generation of research tools and techniques to “help researchers ask more incisive and convergent research questions” and enable a more comprehensive analysis “of the massive amounts of heterogeneous data generated automatically by online networks.”

A broad array of online PD programs is currently serving large numbers of teachers. These programs are diverse in their purposes and goals, content areas, pedagogical approaches, and delivery methods. As one example, the PBS TeacherLine site offers more than 100 online PD courses to PreK-12 teachers in the fields of mathematics, reading and language arts, science, instructional technology, and instructional sciences. These relatively short courses were developed with input from K-12 educational leaders and research experts and

include online discussions with trained facilitators who have backgrounds in the subject matter. Designed to tie to classroom practice and link content to local and national standards, many of the courses feature streaming video of classrooms and digitized versions of student work (Ramsdell, Rose, & Kadera, 2006). Dede and colleagues (this issue) point out that although such online PD programs are growing rapidly and becoming increasingly popular, very little research has been conducted to examine their effectiveness. Like Schlager and colleagues, they call for a research agenda and additional resources to identify the design and implementation features that support teacher change and student learning.

We, too, have been struck by the gap between development of new tools and online experiences and research efforts to examine their effectiveness. Looking across the different uses of digital technology in teacher education, we note several issues that must be addressed to begin to realize the potential of technology to support teacher learning. These issues (e.g., differences between online facilitation and face-to-face facilitation, expertise needed by online facilitators, changes in teacher knowledge and skills, impact on student learning) may be fruitful avenues for research.

Supporting Teachers' Integration of Technology in Classroom Teaching

Another avenue for exploration, not addressed in this issue's call for manuscripts, but equally important to the success of technology integration in education, is the knowledge and skills that teachers must have to use technology effectively in their teaching. This question is on the minds of policy makers, practitioners, and scholars alike. The second edition of the *National Educational Technology Standards for Teachers*, published by the International Society for Technology in Education (2008), specifies that teachers be able to demonstrate and promote the effective use of digital tools and resources as they

- Facilitate and inspire student learning and creativity;
- Design and develop Digital Age learning experiences and assessments;
- Model Digital Age work and learning;
- Promote and model digital citizenship and responsibility; and
- Engage in professional growth and leadership

These standards nudge the field forward by emphasizing digital media and Web-based learning and by establishing an expectation that all teachers will be tech-savvy in the ways we have outlined earlier. Forty-four states currently

have standards for teachers that include technology, most of which are aligned with these national standards (Editorial Projects in Education Research Center, 2008).

The recently published *Handbook of Technological Pedagogical Content Knowledge (TPACK) for Educators* (AACTE Committee on Innovation and Technology, 2008) also pushes the field forward. A central premise of the handbook is that TPACK is the key to successful curriculum-based technology integration. Two years ago, Mishra and Koehler (2006) introduced TPACK to the educational community—a compelling conceptualization of the unique knowledge teachers need to develop to embed technology in their instructional practice so that it fosters student learning. They argued that thoughtful pedagogical uses of technology require TPACK and that the development of TPACK by teachers is critical to effective teaching with technology. They further develop this argument in their introductory chapter for the handbook, providing a conceptual framework that extends Shulman's (1986) conceptualization of the domains of professional knowledge for teaching into the realm of technology integration. The concept of TPACK is described as the domain of teacher knowledge that lies at the intersection of three major components of learning environments: content, pedagogy, and technology. TPACK includes

. . . an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face; knowledge of students' prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge and to develop new epistemologies or strengthen old ones. (pp. 17-18)

Tech-savvy teachers have well-developed TPACK. In the next section, we draw on ideas in the *Handbook* and the articles in this theme issue, as well as our own experiences and conversations with colleagues, to highlight issues to consider in designing programs that foster the development of TPACK and promote successful technology integration.

Looking to the Future

Many of the issues that must be considered in designing preservice and inservice experiences to support successful technology integration stem from the realization that teaching with technology is a "wicked problem" for both teachers and teacher educators (Koehler & Mishra, 2008). New digital technologies create a number of challenges, as

well as opportunities, for teacher educators. New digital tools can transform the content of teacher education, as they allow for more complex, layered representations of teaching and learning. Teacher educators are just learning to grapple with how to guide candidates to navigate and learn within these representational spaces. Relatedly, teacher educators must become familiar with technologies for K-12 classrooms and consider how to support teachers in understanding how to use them effectively in classrooms. In addition, teacher educators must learn the technical aspects of using and teaching with new digital tools. The many dynamic factors and conditions that must be considered in designing technology solutions, combined with the inherent instability of digital technologies, make the learning process a challenging one. And the fact that many teacher educators are digital “immigrants” rather than digital “natives” (i.e., they have not grown up surrounded by digital technologies) intensifies this challenge (Prensky, 2001). Finally, teacher educators must collaborate with colleagues in programs and departments across campuses to forge a coherent and developmental vision for how they will integrate digital technologies that support the development of tech-savvy teachers.

In the next 5 years, for the field of teacher education to realize the potential of newer digital technologies, we need to energize all teacher educators to engage in more tech-savvy practices and to conduct quality research that provides guidance in resolving the wicked problems around developing tech-savvy teachers who can use these technologies. The issues and barriers noted above suggest several important concerns to attend to as we move forward in our program design and research efforts. These considerations are applicable both to programs that use technology to support teacher learning and to those that support teachers using technology in their teaching. We hope that you find the articles inspire you to consider ways in which your practice and/or program is actively engaged in the work of preparing tech-savvy teachers. We also hope that the articles help researchers understand the complex of variables and their interdependent nature when designing studies of innovative uses of technology in teaching and teacher education.

Note

1. As evidence for this interest, we highlight several policy efforts centered on technology. As part of the No Child Left Behind Act of 2001, the Enhancing Education through Technology Program was established with the primary goal of improving students' academic achievement through the use of technology in K-12 schools. Similarly, in the latest reauthorization of the Higher Education Act, the National Center for Research in Advanced Information and Digital Technologies was established to

... support a comprehensive research and development program to harness the increasing capacity of advanced information and digital technologies to improve all levels of learning and education, formal and informal, in order to provide Americans with the knowledge and skills needed to compete in the global economy. (H.R. 4137, 2008, p. 369)

Numerous organizations and publications are also devoted to enhancing the use of technology in education. For example, the Association for the Advancement of Computing in Education, an international educational organization whose mission is to advance the use of information technology in education, provides international conferences, publications, a digital library, career center, and other opportunities for professional growth. Its portfolio includes several journals whose purpose is to advance theory, research, and/or practice on using technological tools to support learning, teaching, and teacher education. Most relevant to our interests, the *Journal of Technology and Teacher Education* “provides a forum for the exchange of knowledge about the use of technology in [both preservice and in-service] teacher education.”

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