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ORIGINAL PAPER

Technology and Teacher Education: A Brief Glimpse of the Research and Practice that Have Shaped the Field

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Abstract Technology integration, an integral component of teaching and learning, has been widely investigated during the past several decades as teacher education programs have struggled to implement and model best teaching technology integration practices in the preparation of pre-service teachers. Initiatives led by educational organizations at the federal, state, and local levels have recognized these challenges and have, in response, allocated time, money, and effort to develop and incorporate methods to better prepare pre-service teachers to teach with technology. This report provides a brief glimpse at a number of these initiatives and reforms developed by the government, national professional organizations, accreditation agencies, and business collaborations that affect and strengthen the adoption of technology in teacher education programs.

Keywords Technology integration · Teacher education program · Pre-service training · Technology initiatives

Introduction

Computer technology has an almost 50-year history in education. The earliest reference to educational technology was made by a radio instruction pioneer, W. W. Charters, in an interview in 1948 (Saettler 1990). Technological innovations, however, such as the introduction of radios in the 1920s, movies in the 1930s, televisions in the 1950s, computers in the 1960s, and the Internet and World Wide Web in the 1990s have not achieved the promised effect of improving teaching and learning (Cuban 1993). Advances in technology and the development of new and powerful educational tools brought technology integration into instructional practices. For example, the Programmed Logic for Automatic Teaching Operations (PLATO), the first computer-based education system (Molnar 1997), was developed at the University of Illinois at Urbana_Champaign in 1960. PLATO provided automated individual instruction that allowed students to work at their own pace and seek help when needed (Troutner 1991). Since the development of PLATO, new technologies emerged and research on the integration of technology in education has attracted significant attention.

Initiatives led by educational organizations at the federal, state, and local levels have established and encouraged the adoption of technology (Bakir 2015). These organizations have also devoted extensive amounts of time, money, and effort to develop and integrate different frameworks and policies to encourage the use of technology in teacher training and K–12 settings. The purpose of this report is to provide a brief glimpse at a number of these various initiatives and reforms developed by the government, national professional organizations, accreditation agencies, and business collaborations that affect and strengthen the adoption of technology in teacher training. Some of the initiatives discussed in this paper focus on K–12 students and in-service teachers' professional development. These initiatives are included because, first, teacher education programs need to know what takes place in schools in order to focus on the needs of the students that prospective teachers will teach, and, second, education programs can drastically influence and strengthen the direction of K–12 technology use by training teachers who have the knowledge and skills to incorporate technology into their teaching.

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Federal Initiatives and Reforms

Technology in teaching and learning became a national priority in 1983 when the National Commission on Excellence in Education issued *A Nation at Risk: The Imperative for Educational Reform*, which investigated the problems affecting the U.S. educational system and offered solutions. The commission recommended that high school graduation requirements include a computer course and that new instructional materials should integrate the current applications of technology in teaching (National Commission on Excellence in Education 1983). By the late 1980s and mid-1990s, the federal government took a proactive approach to examine the status of technology integration in teacher education programs. For example, the 1988 national study, *Power On! New Tools for Teaching and Learning*, conducted by the Office of Technology Assessment (OTA), looked at teachers' needs for training and the role that teachers play when adopting technology in classroom environments. This study was important because it showed that "the vast majority of those now teaching or planning to teach have had little or no computer education or training" (U.S. Congress, OTA 1988, p.18). The report also indicated that teachers should be exposed to ongoing training to learn about how to implement technology in the classroom. Another national study conducted by the OTA (1995) was *Teachers and Technology: Making the Connection*, which focused on the use of technology in teacher education. The findings showed the importance of how teacher training influenced the effective uses of technology in schools. However, it found that technology was not common in most teacher training programs. Specifically, the study revealed that technology was typically not emphasized as a learning tool. In fact, only three percent of teacher education graduates felt very well prepared to use technology in the classroom. The study concluded that "most new teachers graduate from teacher preparation institutions with limited knowledge of ways technology can be used in professional practice" (U.S. Congress, OTA 1995, p. 165). Similar to the 1988 report, the 1995 study showed that K–12 teachers learned little about the potential of technology and its application in teaching and learning.

National Technology Plans

The two OTA reports prompted further investigations of national technology plans to determine how technology was being taught and adopted in American education. One such initiative was the release of the first national technology plan, *Getting America's Students Ready for the 21st Century: Meeting the Technology Literacy Challenge* in 1996. Aiming to improve the technological literacy of students, the initiative addressed how students were taught how to use computers and other technologies to guide learning, productivity, and performance (U.S. Department of Education 1996). The plan also stressed the importance of improving teacher training by providing the hardware and software to instruct teachers how to connect their classrooms to the Internet. Particularly, in regards to teacher training, the plan emphasized that improving teacher training was essential if pre-service teachers were to use and adopt technology in meaningful and effective ways to enhance student learning. Four goals were introduced:

1. All teachers in the nation will have the training and support they need to help students learn using computers and the information superhighway.
2. All teachers and students will have modern multimedia computers in their classrooms.
3. Every classroom will be connected to the information superhighway.
4. Effective software and online learning resources will be an integral part of every school's curriculum (U.S. Department of Education 1996, p. 5).

Following this initial 1996 plan, the U.S. Department of Education published three subsequent plans in 2000, 2004, and 2010. Each plan made the adoption of technology in American classrooms as part of a national mandate and was developed based on the recommendations of its predecessors.

The 2000 National Educational Technology Plan, *E-Learning: Putting a World-Class Education at the Fingertips of All Children*, focused on the idea that technology was an essential part of school improvement and the need for providing students with "new 21st-century literacy" skills. This plan bolstered the tenets of the 1996 plan, and it suggested that studies be undertaken to determine the classroom environments in which technology adoption would be most successful. With specific focus on teacher training, the plan reported that "new teachers entering the profession are still not being adequately prepared to teach with technology . . . fewer than half of the nation's teacher preparation institutions require students to design and deliver instruction using technology, and that even fewer require technology use in the student teaching experience" (U.S. Department of Education 2000, p. 14). The plan included five new technology goals:

1. All students and teachers will have access to information technology in their classrooms, schools, communities and homes.
2. All teachers will use technology effectively to help students achieve high academic standards.
3. All students will have technology and information literacy skills.
4. Research and evaluation will improve the next generation of technology applications for teaching and learning.
5. Digital content and networked applications will transform teaching and learning (U.S. Department of Education 2000, p. 6).

The third plan, *Toward a New Golden Age in American Education: How the Internet, the Law and Today's Students Are Revolutionizing Expectations*, was published in 2004 and focused on online instruction (e-learning) and virtual schools. The plan reported that K–12 students were not using technology, due mainly to paucity in the lack of technology instruction in preservice teacher programs. The plan recommended revolutionizing schooling by strengthening leadership, preparing innovative budgeting plans, improving teacher training, supporting e-learning and virtual schools, and encouraging broadband access, and ultimately moving toward the use of digital content and the integration of data systems (U.S. Department of Education 2004). A major influence of this technology plan was the No Child Left Behind Act of 2001 (NCLB), which mandated improvements in student academic achievement by 2014, measured by rigorous testing. NCLB included specific technology mandates, recommending that by the end of the eighth grade, all students should be technologically literate. In regards to teacher education, the NCLB stated that advanced technology was a key tool for the implementation of new curricula "to meet challenging state and local academic content and student academic achievement standards," and called for "tech-savvy" leadership within the schools and teacher technology training (NCLB Sec. 1051).

The fourth plan, *Transforming American Education: Learning Powered by Technology*, was published in 2010 and continued to address technology in teacher training by pointing out that "technology should be used in the preparation and ongoing learning of educators to engage and motivate them in what and how they teach" (U.S. Department of Education 2010, p. 16). It also presented a technology-powered model of learning for the 21st century, detailing goals for learning, assessment, teaching, infrastructure, and productivity. These goals were:

1. Learning: Engage and Empower: All learners will have engaging and empowering learning experiences both in and out of school that prepare them to be active, creative, knowledgeable, and ethical participants in our globally networked society.
2. Assessment: Measure What Matters: The education system at all levels will leverage the power of technology to measure what matters and use assessment data for continuous improvement.
3. Teaching: Prepare and Connect: Professional educators will be supported individually and in teams by technology that connects them to data, content, resources, expertise, and learning experiences that can empower and inspire them to provide more effective teaching for all learners.
4. Infrastructure: Access and Enable: All students and educators will have access to a comprehensive infrastructure for learning when and where they need it.
5. Productivity: Redesign and Transform: The education system at all levels will redesign processes and structures to take advantage of the power of technology to improve learning outcomes while making more efficient use of time, money, and staff (U.S. Department of Education 2010, Executive Summary).

A close examination of the national technology plans shows common themes and changes in focus for technology in education. The first plan focused on improving technological literacy. Subsequent plans continued this focus but shifted toward the increased adoption of technology in the classroom, which occurred in tandem with technological advances. The initiatives highlighted the fact that new teachers were still not adequately prepared to adopt technology in their future classrooms. Current initiatives focus on the use of technology in teacher education to engage and motivate teachers in terms of both what and how they teach. This approach establishes a 21st century model of learning which focuses on connected teaching.

Funding Initiatives

A variety of funding opportunities were offered to colleges, universities, and K–12 schools to increase the implementation of technology. For example, in response to the first national technology plan of 1996, the federal government launched the Technology Literacy Challenge Fund (TLCF) in 1997. This five-year, $2 billion initiative allowed states and districts to achieve the goals detailed in the 1996 technology plan. The goals were to increase classroom instruction and to help students become technologically literate as technology became increasingly incorporated in the classroom (U.S. Department of Education 2007). Another important funding opportunity was initiated in 2002: the Enhancing Education Through Technology program (EETT), which was the successor of the TLCF program. The EETT program was approved by Title II, Part D, of the Elementary and Secondary Education Act of 1965 (ESEA), as amended by NCLB (U.S. Department of Education 2009). The program aimed to improve student academic achievement in schools through technology integration. The program also focused on empirically-based methods to train and develop curricula for prospective teachers. In order to accomplish these goals, funding was provided for infrastructure, professional development, and program evaluations. The first year's funding was just over $700 million; however, program funding declined in each subsequent year, with the most significant decline occurring in 2006. Between 2002 and 2008, approximately $3.4 billion was allocated to EETT (U.S. Department of Education 2009). Although funding for the program was eliminated in 2011, legislation mandated reactivation of the program in fiscal year 2016 (Schaffhauser 2015). Although these two funding initiatives focused on K–12, they both highlighted the importance of teachers' ongoing professional development to encourage

technology integration and to improve student academic achievement.

With respect to teacher training, the Department of Education's Preparing Tomorrow's Teachers to Use Technology (PT3) provided a critical funding opportunity in 1999. PT3 awarded $750 million in grants to higher-education institutions, state agencies, school districts, and non-profit organizations to transform pre-service teachers' technology-integration experiences (U.S. Department of Education 2005). Projects included faculty development, course restructuring, certification policy changes, online teacher preparation, enriched-networked-virtual, video case studies, electronic portfolios, mentoring, and embedded assessments. Lessons learned from PT3 projects indicated that the most prevalent and successful strategies for technology integration involved professional development for college of education faculty, collaboration for curriculum reform, and the provision of incentives (Duffield & Moore 2006). Due to the limited amount of empirical evidence about the impact of these initiatives (Mims, Polly, Shepherd, & Inan 2006), it remains unclear whether or not the funded projects helped pre-service teachers become successful users of technology (Clausen 2007). Even though the majority of the PT3 projects ended, the National Technology Leadership Summit (NTLS), one of the most influential PT3 initiatives developed, continues. Established in 2000 by the University of Virginia Curry School of Education, NTLS is a modern forum that promotes technology adoption in teacher education across different disciplines. The National Technology Leadership Coalition (NTLC), established by the Society for Technology and Teacher Education (SITE), is a consortium of national teacher educator associations and national technology associations that provides cross-disciplinary focus on technology and teacher education. The NTLS, which serves as the annual meeting of NLTC, brings together leaders of educational associations, educational technology journal editors, non-profit foundation directors, federal policymakers, and corporate representatives. NTLS is instrumental in setting the directions for work in technology and teacher education. For example, the NTLS Fall 2014 meeting focused on informal learning, make to learn, and personalized learning technologies and how these topics could be applied to the preparation of pre-service teachers (NTLS 2000–2013).

National Professional Organizations, Teacher Education Accreditation Agencies, and Business Collaborations

ISTE Standards

In addition to the efforts made by the federal government, businesses, national professional organizations, and teacher education accreditation agencies also attended to the need to prepare teachers to integrate technology into their teaching. The International Society for Technology in Education (ISTE), a non-profit organization, was the first organization to recognize the emerging needs of technology and teacher education in 1998. ISTE published its first set of technology standards for K−12 students (National Education Technology Standards for Students [NETS−S]) to encourage the use of technology in K–12 education (ISTE 1998). NETS−S described the technology skills and knowledge required by students. From these standards came NETS for Teachers (NETS−T) in 2000 and NETS for Administrators (NETS−A) in 2002. The NETS−T standards established the groundwork for teacher education programs and defined the fundamental concepts, knowledge, skills, and attitudes for applying technology in schooling. They also laid out what new teachers should be able to do with technology upon entering the classroom (ISTE 2000). The NETS−A standards described what administrators needed to know, as well as what they should be able to do as leaders who can effectively use technology in schools. Over the years, these standards have been revised in order to meet the rapid changes in technology development, student demographics, and the shift in technology's role in education, as well as the increased use of technology in K–12 education. Revisions were made to NETS−S in 2007, NETS−T in 2008, and NETS–A in 2009. With the new standards, the focus shifted from learning about technology to learning with technology in order to "truly provide students the opportunity to learn effectively for a lifetime and live productively in our emerging global society and increasingly digital world" (ISTE 2007, p. 1). Overall, these three standards provide systematic ways to adopt and integrate technology in the classroom. The National Education Technology Standards have since been renamed the ISTE Standards.

ISTE Standards and Teacher Education Accreditation Agencies

A major shift occurred with the establishment of the ISTE standards. The National Council for Accreditation of Teacher Education (NCATE), seeing the need to create a vision of teacher education programs that fully integrated and used technology, adopted the ISTE standards and required teacher education programs restructure their programs accordingly. These standards described the essential conditions needed to support technology use in teacher education programs and provided a foundation for technology use for all teachers. As part of the accreditation process for teacher preparation programs, pre-service teachers were expected to be proficient in technology integration in both teaching and learning.

In 1997, through its examination of the accreditation program, the NCATE Task Force on Technology and Teacher Education found that pre-service teachers were seldom required to apply technology. The report concluded, "The

nation's teacher education institutions must close the teaching and learning technology gap between where we are not and where we need to be . . . Teacher education institutions must prepare their students to teach in tomorrow's classrooms" (NCATE 1997, p. 3). The recommendations included (a) stimulating more effective uses of technology in teacher education programs; (b) using technology to improve the existing accreditation process and to reconceptualize accreditation for the 21st century; and (c) improving and expanding its own operations through greater uses of technology (NCATE 1997). On July 1, 2013, NCATE merged with the Teacher Education Accreditation Council (TEAC). TEAC, a non-profit organization, is dedicated to improving academic degree programs for professional educators. The merger created the Council for the Accreditation of Educator Preparation (CAEP), which succeeds NCATE. Currently, TEAC is the only recognized organization that accredits U.S. teacher education programs. Because NCATE had accepted the ISTE standards in Fall 2012, these are now the CAEP standards. Their importance is that they identify the skills, knowledge, and approaches that students, educators, and leaders need to possess to be successful in the digital age.

Business Collaborations

At roughly the same time as the establishment of the first technology plan in 1996, the CEO Forum on Education and Technology was founded. The Forum was a five-year partnership between businesses and education leaders committed to assessing and applying technology in America's schools. The Forum included executives from Apple, BellSouth Business, Verizon, Dell Computer Corporation, IBM, Hewlett-Packard, and other corporations. Even though the purpose of the Forum was to improve technology integration in K–12 schools, interestingly, only one educational representative from the National Education Association and the National School Boards Association participated. While the forum provided valuable input on how to maximize student achievement with technology use, it also served as a good example of how businesses had a vested interest in the use of technology in both teaching and learning and how technology in general could ultimately impact technology in education. The Forum issued five reports on different aspects of technology integration in education. The first report, *School Technology and Readiness Report: From Pillars to Progress*, highlighted the long-term benefits of technology in education, focusing on hardware, connectivity, and professional development (CEO Forum 1997). The second report, *Professional Development: A Link to Better Learning*, discussed how essential professional development was for the successful adoption and implementation of technology in both preservice and in-service and how technology maximized student achievement (CEO Forum 1999). The Forum recommended that teacher education programs prepare new teachers to integrate technology effectively into the curriculum. The Forum produced *Teacher Preparation STaR Chart: A Self-Assessment Tool for Colleges of Education*, which grew out of the second report, to address the lack of technology adoption in teacher education programs (CEO Forum 2000a). The chart provided guidelines for teacher education programs to measure the level of readiness of their programs to integrate technology into their programs. Unlike the reports, *Teacher Preparation STaR Chart* was collaboratively developed by deans, faculty members, students, superintendents, educators, and business community members (CEO Forum 2000a). The third report, *The Power of Digital Learning: Integrating Digital Content*, offered a vision that encompassed the use of digital learning and the development of skills needed for students to be well prepared for technological advances in the 21st century (CEO Forum 2000b). The fourth report, *21st Century Accountability*, outlined objectives for schooling that could be achieved using technology in the classroom, while highlighting the changes that must occur in assessment to ensure that students develop skills relevant to the 21st century (CEO Forum 2001).

Collectively, these reports illustrated the national emphasis on accountability for ensuring K–12 student achievement, and they focused on different aspects of educational technology, ranging from students' academic performance, professional development, federal funding, and infrastructure, to research and development. The second report generated awareness of the status of technology integration in teacher training and identified the preparation of a new generation of teachers as "a national crisis" (CEO Forum 1999, p. 4). The development of the *Teacher Preparation STaR Chart* drew national attention to the need for all teachers to effectively use technology. This chart guided teacher education programs determine their current standing and to plan future direction in all aspects of teacher training.

The CEO Forum offered three major recommendations: (a) broaden student achievement to include 21st century skills, which should be included in the ISTE standards, curriculum, and assessment; (b) expand federal support for education technology investments, and emphasize equity in funding, ensuring that those schools with the greatest need benefit most from federal education technology programs; and (c) increase investment in research, development, and dissemination to determine effective technology methods to improve student achievement, while supporting the development of assessment tools that measure 21st century skills.

The following year, in 1998, another business collaboration took place. ISTE partnered with the Milken Exchange on

Educational Technology group and created a 32-item survey for schools, colleges, and departments of education to determine the extent to which students were being exposed to technology in their classes, field experiences, and curriculum materials. Four hundred and sixteen institutions across the country responded to the survey. The findings showed that teacher education faculty possessed technology skills that were comparable to those of the pre-service teachers they taught, but that the faculty did not model the use of technology in their teaching. A large gap appeared between what K–12 students needed to know about technology and what teacher education programs were actually teaching. Programs did not prepare pre-service teachers to use technology in their classrooms. The study concluded, "In order to provide models for change, researchers, professional societies, and education agencies should identify, study, and disseminate examples of effective technology integration that reflect the current needs in both teacher education and K–12 schools" (Moursund & Bielefeldt 1999, p. 10). They further stated that "Organization [s] such as NCATE and ISTE, through their roles in establishing and disseminating standards for educational technology, have an important part to play in encouraging and facilitating change (p. 31)." These findings were important because they provided insights into the status of technology integration in teacher training.

In 2002, another business and education coalition was established: the Partnership for 21st Century Skills (P21), which brought together the business community, education leaders, and policymakers to explore 21st century readiness in K–12 education. In 2009, P21 developed a list of skills that students must possess in order to compete in the global workplace, such as information media and technology, and learning and innovation skills, global awareness, and civic literacy. To effectively teach these skills, it was proposed that teachers required a 21st century support system. P21 identified five such support systems: 21st century standards; assessment of 21st century skills; 21st century curriculum and instruction; 21st century professional development; and 21st century learning environments. The American Association of Colleges for Teacher Education (AACTE) and P21 both adopted the perspective that "new teacher candidates must be equipped with 21st century knowledge and skills and learn how to integrate them into their classroom practice for our nation to realize its goal of successfully meeting the challenges of this century" (P21 2010, p. 3). This partnership set out the following core principles, representing a shared vision for integrating 21st century skills into teacher training:

1. Educator preparation programs will prepare their graduates to possess, teach and assess 21st century knowledge and skills.
2. New teachers will be prepared to become change agents for embedding 21st century knowledge and skills in all subjects in P-12 curricula in accordance with national and state standards.
3. Each educator preparation program will develop a 21st century blueprint for transforming itself into a 21st century program.
4. Each educator preparation program will develop a 21st century blueprint for transforming itself into a 21st century program.
5. Educator preparation programs will be recognized as sources of leadership in developing 21st century education and learning strategies.
6. Educator preparation programs will be at the forefront of research and evaluation of 21st century education (Partnership for 21st Century Skills 2007).

This collaboration promoted the formal inclusion of 21st century knowledge and skills into teacher education programs.

Approaches to Technology Integration in Pre-service Teacher Training

Teacher education programs are constantly being challenged to prepare future teachers who can effectively integrate technology in their teaching. Debate continues about the most effective ways to integrate technology integration in teacher education (Kay 2006). Technology integration via a single course was the earliest and most typical approach (Handler & Strudler 1997; Hargrave & Hsu 2000; Honawar 2008; O'Bannon & Puckett 2007). However, studies showed that pre-service teachers did not benefit from single technology courses because learning in isolation did not provide them with the necessary skills and the abilities to integrate technology into their practice (Bakir 2015; Wachira & Keengwe 2011). Different approaches and strategies followed to better prepare students to teach with technology. Kay (2006) identified ten key technology integration strategies used in teacher training programs. These strategies included delivering a single technology course; offering mini-workshops; integrating technology in all courses; modeling how to use the technology; using multimedia; encouraging collaboration among pre-service teachers, mentor teachers, and faculty; practicing technology in the field; focusing on education faculty; focusing on mentor teachers in K–12 settings; and improving access to software, hardware, and/or technical support. In a recent meta-analysis of more than 100 programs, Ottenbreit-Leftwich et al. (2010) outlined a series of approaches to integrating technology in teacher training including "information delivery of technology integration content, hands-on technology skill building activities, practice with technology integration in the field, technology integration observation or modeling sessions, authentic technology integration experiences, and technology integration reflections" (p. 10).

Although there is no consensus regarding the best approach (Kay 2006), there appears to be a common sense in the field is that technology training should be integrated throughout the entire program (U.S. Department of Education 2010). Still, research has consistently illustrated that pre-service teachers are not being adequately prepared to integrate technology in their future classrooms (Bakir 2015; Gray, Thomas, & Lewis 2010; Kay 2006; Ottenbreit-Leftwich et al. 2010).

To ensure that pre-service teachers are prepared to integrate technology into their teaching, a number of researchers noted that specialized technology training should be mandatory in the teachers' college curriculum (Angeli & Valanides 2009; Banister & Reinhart 2012). Technological pedagogical content knowledge (TPACK) was introduced to the field as a theoretical framework to help understand teachers' knowledge for effective technology integration by Mishra and Koehler in 2006 (Mishra & Koehler 2006). TPACK builds upon Shulman's (1987) pedagogical content knowledge and conceptualizes how a teacher's content knowledge, pedagogy, and technology work together to design discipline-specific technology learning experiences. The TPACK framework is currently being used to describe what teachers need to know to effectively integrate technology into their classroom lessons. Schmidt, Baran, Thompson, Mishra, Koehler, and Shin (2009) developed the Survey of Pre-service Teachers' Knowledge of Teaching and Technology instrument to measure pre-service teachers' self-assessments of their TPACK knowledge. As such, the TPACK instrument has since been used and modified to enhance current teaching practices. Many research studies within the TPACK framework have looked at different disciplines: science (Jimoyiannis 2010; Khan 2011; Syh-Jong 2010; Trautmann & MaKinster 2010); mathematics (Browning & Carza-Kling 2010; Hardy 2010; Richardson 2009); social studies (Brush & Saye 2009; Bull et al. 2008; Harris & Hofer 2011; special education (Marino, Sameshima, & Beecher 2009). instructional technology (Niess 2005; Thompson & Mishra 2007; Wetzel, Foulger, & Williams 2008).

Although the TPACK framework predicts effective technology use in teaching, more research is needed. The focus of pre-service teachers' training has shifted from instructing teachers on how to use technology to encouraging teachers to think critically about using technology in the classroom as a learning tool. In this way, a new framework for teacher knowledge has emerged, one more in line with the current technological advances of the 21st century.

Discussion and Conclusion

Since the 1980s, technology integration has been central to the discourse on schools and teacher training. Emphasis on the effective integration of technology in K–12 schools to maximize student achievement has increased the urgency to prepare teachers who know how to effectively use technology in their teaching. Pre-service teacher education programs can significantly improve K–12 technology use by training teachers to use technology to enhance teaching and learning. This is especially the case if these teachers have the knowledge and skills to use and integrate technology in the classroom. The need to prepare pre-service teachers to use technology effectively has received attention from various federal initiatives, national professional organizations, accreditation agencies, and business collaborations. The efforts discussed in this paper show that pre-service teachers are expected to use technology in their practices. Teacher training programs are the obvious place to introduce teachers to technology; nevertheless, teachers still struggle to adapt their own skills to match those of 21st century learners (Kay 2006).

The status of technology in teacher education first received the attention with the first OTA report in 1995. This report was crucial because it showed that the majority of new teachers had limited experience with technology in their training. Since this report, a variety of approaches and frameworks have been designed and used to help teacher educators integrate technologies in the preparation of pre-service teachers. Teacher education programs however still face the same problems they did since the OTA's 1995 study, despite the various initiatives and funding opportunities. The U.S. Department of Education has continued to take a proactive approach by developing initiatives to leverage widespread educational opportunities in teaching and learning guided by the effective use of technology.

In order to improve the effectiveness of teacher education programs to successfully integrate technology, Moursund and Bielefeldt (1999) made three recommendations: (a) integrate instructional technology into all teacher education courses; (b) have teacher education faculty members model technology-integrated teaching and learning; and (c) encourage field experiences with mentor teachers who support and encourage students as they practice teaching with technology. Even though these recommendations were developed and presented in the 1990s, they are still valid today and are confirmed by other research.

In conclusion, this paper provides a brief glimpse of the various initiatives developed by the government, national professional organizations, accreditation agencies, and business collaborations that affect and strengthen the adoption of technology in teacher education programs. Progress has been made. As future educational initiatives continue to build upon preceding ones, widespread technology integration in teacher education becomes more possible. This shift in technology adoption will continue to guide and influence both research and practice, as teachers and teacher educators work together to seamlessly teach and incorporate technology use in the classroom.

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References

Angeli, C., & Valanides, N. (2009). Epistemological and methodological issues for the conceptualization, development, and assessment of ICT–TPCK: advances in technological pedagogical content knowledge (TPCK). *Computers & Education, 52*, 154–168.

Bakir, N. (2015). An exploration of contemporary realities of technology and teacher education: lessons learned. *Journal of Digital Learning in Teacher Education, 31*(3), 117–130.

Banister, S., & Reinhart, R. V. (2012). Assessing NETS-T performance in teacher candidates: exploring the wayfind teacher assessment. *Journal of Digital Learning in Teacher Education, 29*(2), 59–65.

Browning, C. A., & Carza-Kling, G. (2010). Graphing calculators as tools. *Mathematics Teaching in the Middle School, 15*(8), 480–485.

Brush, T., & Saye, J. W. (2009). Strategies for preparing preservice social studies teachers to integrate technology effectively: models and practices. *Contemporary Issues in Technology and Teacher Education* [Online serial], *9*(1). Retrieved from http://www.citejournal.org/vol9/iss1/socialstudies/article1.cfm.

Bull, G., Hammond, T., & Ferster, B. (2008). Developing web 2.0 tools for support of historical inquiry in social studies. *Computers in the Schools, 25*(3), 275–287.

CEO Forum on Education and Technology (1997). *School technology and readiness report: from pillars to progress.* Retrieved from http:// www.ceoforum.org/reports.cfm

CEO Forum on Education and Technology (1999). *Professional development: a link to better learning.* Retrieved from http:// www.ceoforum.org/reports.cfm

CEO Forum on Education and Technology (2000a). Teacher preparation STaR chart: *a self-assessment tool for colleges of education.* Retrieved from http:// www.ceoforum.org/reports.cfm

CEO Forum on Education and Technology (2000b). *The power of digital learning: integrating digital content.* Retrieved from http:// www.ceoforum.org/reports.cfm

CEO Forum on Education and Technology (2001). *21st century accountability.* Retrieved from http:// www.ceoforum.org/reports.cfm

Clausen, J. M. (2007). Beginning teachers' technology use: first-year teacher development and the institutional context's affect on new teachers' instructional technology use with students. *Journal of Research on Technology in Education, 39*(3), 245–261.

Cuban, L. (1993). Computers meet classroom: classroom wins. *Teachers College Record, 95*(2), 185–210.

Duffield, J. A., & Moore, J. A. (2006). Lessons learned from PT3. *TechTrends, 50*(3), 54–56.

Gray, L., Thomas, N., & Lewis, L. (2010). *Teachers' use of educational technology in U.S. public schools: 2009* (NCES 2010-040). National Center for Education Statistics, Institute of Education Sciences, Washington, DC. U.S. Government Printing Office.

Handler, M. G., & Strudler, N. (1997). The ISTE standards: issues of implementation. *Journal of Computing in Teacher Education, 13*(2), 16–23.

Hardy, M. (2010). Enhancing preservice mathematics teachers' TPCK. *Journal of Computers in Mathematics and Science Teaching, 29*(1), 1–14.

Hargrave, C. P., & Hsu, Y. (2000). Survey of instructional technology courses for pre-service teachers. *Journal of Technology and Teacher Education, 8*(4), 303–314.

Harris, J. B., & Hofer, M. J. (2011). Technological pedagogical content knowledge (TPACK) in action: a descriptive study of secondary teachers' curriculum-based, technology-related instructional planning. *Journal of Research on Technology in Education, 43*(3), 211–229.

Honawar, V. (2008). Learning to teach with technology. *Education Week, 30*.

International Society for Technology in Education (ISTE). (1998). *National education technology standards for students*. Eugene: International Society for Technology in Education.

International Society for Technology in Education (ISTE). (2000). *National educational technology standards for teachers: resources for assessment*. Eugene: International Society for Technology in Education.

International Society for Technology in Education (ISTE). (2007). *National educational technology standards for students (2nd ed.)*. Washington, DC.

Jimoyiannis, A. (2010). Designing and implementing an integrated technological pedagogical science knowledge framework for science teachers' professional development. *Computers & Education, 55*(3), 1259–1269.

Kay, R. H. (2006). Evaluating strategies used to incorporate technology into preservice education: a review of the literature. *Journal of Research on Computing in Education, 38*(4), 383–408.

Khan, S. (2011). New pedagogies on teaching science with computer simulations. *Journal of Science Education and Technology, 20*(3), 215–232.

Marino, M. T., Sameshima, P., & Beecher, C. C. (2009). Enhancing TPACK with assistive technology: promoting inclusive practices in preservice teacher education. *Contemporary Issues in Technology and Teacher Education*, *9*(2). Retrieved from http://www.citejournal.org/vol9/iss2/general/article1.cfm

Mims, C., Polly, D., Shepherd, C. E., & Inan, F. A. (2006). From campus to the field: examining PT3 projects designed to improve preservice teachers' methods courses and field experiences. *Tech Trends, 50*(3), 16–24.

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: a new framework for teacher knowledge. *Teachers College Record, 108*(6), 1017–1054.

Molnar, A. (1997). Computers in education: a brief history. *T.H.E. Journal, 24*(11), 63–68.

Moursund, D. G., & Bielefeldt, T. (1999). *Will new teachers be prepared to teach in the digital age: a national survey on information technology in teacher education*. Santa Monica: Milken Exchange on Information Technology.

National Association for Accreditation of Teacher Education (NCATE). (1997). *Technology and the new professional teacher: preparing for the 21st century classroom*. Washington: NCATE.

National Commission on Excellence in Education. (1983, April). *A Nation at Risk*. Retrieved from http://www.ed.gov/pubs/natAtRisk/risk.html

National Technology Leadership Summit (NTLS). (2000–2013). Retrieved from http://www.ntls.info.

Niess, M. L. (2005). Preparing teachers to teach science and mathematics with technology: developing a technology pedagogical content knowledge. *Teaching and Teacher Education, 21*, 509–523.

No Child Left Behind Act of 2001, Pub. L. No. 107-110 (2002). Retrieved from http://www.ed.gov/policy/elsec/leg/esea02/index.html

O'Bannon, B., & Puckett, K. (2007). *Preparing to use technology: a practical guide to curriculum integration*. Boston: Pearson Education/Allyn and Bacon.

Office of Technology Assessment (OTA) (1995). *Teachers & technology: Making the connection* (Report No. OTA-EHR-616). Washington, DC: U.S. Government Printing Office

Ottenbreit-Leftwich, A., Glazewski, K., & Newby, T. (2010). Preservice technology integration course revision: a conceptual guide. *Journal of Technology and Teacher Education, 18*(1), 5–33.

Partnership for 21st Century Skills. (2007). *Statement of principles: Twenty-first century skills and the reauthorization of NCLB/ESEA*. Retrieved from http://www.21stcenturyskills.org/documents/nclb_memo_and_principles_0807.pdf

Partnership for 21st Century Skills (P21). (2010). *21st Century Knowledge and Skills in Educator Preparation.* Retrieved from http://www.p21.org/storage/documents/aacte_p21_whitepaper2010.pdf

Richardson, S. (2009). Preparing 8th grade mathematics teachers to use technology, pedagogy, and content knowledge in the teaching and learning of algebra. *Contemporary Issues in Technology and Teacher Education, 9*(2), 117-130. AACE.

Saettler, P. (1990). *The evolution of American educational technology.* Englewood: Libraries Unlimited.

Schaffhauser, D. (2015). $1 billion federal 'Enhancing Education Through Tech' Bill introduced. *T.H.E. Journal.* Retrieved from http://thejournal.com/articles/2015/02/12/1-billion-federal-enhancing-education-through-tech-bill-introduced.aspx

Schmidt, D. A., Baran, E., Thompson, A. D., Mishra, P., Koehler, M. J., & Shin, T. S. (2009). Technological pedagogical content knowledge (TPACK): the development and validation of an assessment instrument for preservice teachers. *Journal of Research on Technology in Education, 42*(2), 123–149.

Shulman, L. (1987). Knowledge and teaching: foundations of the new reform. *Harvard Educational Review, 57*(1), 1–22.

Syh-Jong, J. (2010). Integrating the interactive whiteboard and peer coaching to develop the TPACK of secondary science teachers. *Computers & Education, 55*(4), 1744–1751.

Thompson, A. D., & Mishra, P. (2007). Breaking news: TPCK becomes TPACK! *Journal of Computing in Teacher Education, 24*(2), 38–64.

Trautmann, N. M., & MaKinster, J. G. (2010). Flexibly adaptive professional development in support of teaching science with geospatial technology. *Journal of Science Teacher Education, 21*(3), 351–370.

Troutner, J. (1991). *The historical evolution of educational software.* Retrieved from ERIC database. (ED349936)

U.S. Congress, Office of Technology Assessment (1988). *Power on! new took for teaching and learning* (Report No. OTA-SET-379). Washington, DC: U.S. Government Printing Office.

U.S. Congress, Office of Technology Assessment (1995). *Teachers and technology: making the connection* (Report No. OTA-EHR-616). Washington, DC: U.S. Government Printing Office.

U.S. Department of Education (1996). *Getting America's students ready for the 21st century: meeting the technology literacy challenge: a report to the nation on technology and education*. Retrieved from http://www2.ed.gov/about/offices/list/os/technology/plan/national/index.html

U.S. Department of Education (2000). *E-learning: putting a world-class education at the fingertips of all children.* Retrieved from http://files.eric.ed.gov/fulltext/ED444604.pdf

U.S. Department of Education (2004). *Toward a new golden age in American education: how the internet, the law and today's students are revolutionizing expectations.* Retrieved from http://hub.mspnet.org/index.cfm/10128

U.S. Department of Education (2005). *Preparing tomorrow's teachers to use technology program (PT3)*. Retrieved from http://www2.ed.gov/programs/teachtech/resources.html

U.S. Department of Education (2007). *State strategies and practices for educational technology: volume I—examining the enhancing education through technology program*. Washington, D.C.

U.S. Department of Education. (2009). *Evaluation of the enhancing education through technology program: final report*. Retrieved from https://www2.ed.gov/rschstat/eval/tech/netts/finalreport.pdf

U. S. Department of Education (2010). Transforming American education: learning powered by technology. Retrieved from http://www.ed.gov/technology/netp-2010

Wachira, P., & Keengwe, J. (2011). Technology integration barriers: urban school mathematics teachers' perspectives. *Journal of Science Education and Technology, 20*, 17–25.

Wetzel, K., Foulger, T., & Williams, M. (2008-2009, Winter). The evolution of the required educational technology course. *Journal of Computing in Teacher Education, 25*(2), 67-71.