Preparing Teachers for Technology Integration: Programs, Competencies, and Factors from the Literature

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Abstract: This article presents a review of recent literature about preparing teachers for technology integration. The review found six types of training programs are commonly implemented: pre-service training, long-term courses, short-term workshops and institutes, coaching/mentoring, learning communities, and product/assessment approaches. The review summarizes competencies or knowledge gaps that are typically addressed in integration training along with models used to guide teacher understanding. Finally, the review outlines factors found to impact on integration practice, including technology leadership, external/contextual factors, and internal/personal factors. The article concludes with a description of one promising technology integration training program that takes a comprehensive approach to teacher preparation and confronts factors known to impact on integration practice.

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A review of recent literature on technology integration training for pre-service and in-service teachers revealed several popular formats for training, recommendations for training topics and models to guide integration practice, and cautions about influencing factors that can impact on integration practice if not addressed as part of a comprehensive integration program.

Popular Formats for Technology Integration Training Programs

This section describes six popular formats for technology integration training programs that were identified in the literature. It should be noted that these categories are not entirely exclusive. For example, some of the "workshop" approaches are designed to produce "coaches" or master technology-using teachers. Hence, these categories of training programs can overlap and should be considered fluid and complementary in certain cases.

Pre-Service Training Programs

Often a teacher's first exposure to technology is during their teacher training program at an institution of higher education (IHE). In an online survey of faculty responsible for pre-service teacher technology experiences in 407 U.S. teacher preparation programs, Gronseth et al. (2010) found most programs use "standalone educational technology courses," despite the desire by educational technology faculty to integrate technology more systematically in methods courses and field experiences (p. 34). Many have advocated for integrating ICT training across the pre-service teacher curriculum rather than in single technology courses (Belland, 2009; Gronseth et al., 2010; Keeler, 2008). Belland (2009) promotes the idea of collaborative courses where undergraduate pre-service teachers and graduate in-service teachers collaborate around the development of a product (e.g., Web site) that directly addresses some authentic instructional need, providing both technological knowledge and pedagogical modeling.

Hofer (2005) analyzed seven teacher education programs that won ISTE's Distinguished Achievement Award for their work in incorporating national technology standards for teachers (NETS-T). As recommended by many, each award-winning program was praised for incorporating technology standards across a variety of courses (technology, methods, foundational, and student teaching), and the teaching of specific standards occurred in multiple course contexts. Hofer (2005) compared his review of teacher education programs to a prior review conducted in 1994 and noted in both cases the importance of coordinating teacher technology experiences to ensure standards are being met, uniting around a common theme such as portfolio development or technology integration in content-area instruction, and developing a shared vision of expectations with faculty buy-in. Hawley et al. (2003) report on multiple state institutions' efforts to prepare teachers for a new state technology credential, noting a one-size fits all approach was not successful and each institution had to develop their own model for technology preparation (e.g., cohorts, portfolios).

Cohen, Pelligrino, Schmidt, and Schultz (2007) looked at three universities awarded PT3 funds to revision their technology integration efforts across teacher education and identified five common variables. Each institution had a focus on changing the institutional culture to achieve buy-in among faculty with efforts to support faculty through such means as mentoring. Leadership and resources were two other common factors with leaders providing program focus, training, coaching, and time for faculty to make changes. Each institution established a vision based on some conceptual framework (e.g., supporting developmental variation, promoting simultaneous renewal between university and schools). And finally, each institution sought comprehensive change to involve all faculty in their community.

Long-Term Course Approaches

Another approach to technology integration training is a course that tends to be several weeks long and is typically longer than a summer workshop or academy. Both universities and commercial entities offer such course in face-to-face, blended, and fully online formats.

As examples of university-based courses, Keeler (2008) describes the integration of technology lessons into undergraduate social studies methods courses, and key components of the course such as blogs, hands-on technology projects, journaling, concept mapping, and e-portfolios. Summerville and Reid-Griffin (2008) discuss the development of a technology course for pre-service teachers with a series of modules and projects designed to teach technology lesson planning, media evaluation, and core skills with desktop applications (e.g., Microsoft PowerPoint, Excel). Jones, Fox, and Levin (2011) summarized a professional development program in Sumter County, South Carolina, involving 12 middle schools. Teachers enrolled in a graduate-level course to learn about integrating Web 2.0 tools (e.g., wikis, blogs), hardware solutions such as whiteboards, and other video and portfolio products. On-site coaches also worked with teachers outside of the course. Data showed student technology skills and standardized math scores improved in participating schools, and teachers achieved mastery on a state measure of portfolio assessment. Polly (2006) describes the InterMath program of professional development with 45-hours of in-person classes. InterMath courses are touted as learner-centered, since teachers discuss and practice their own mathematical investigations and applications of technology after instructor modeling. A qualitative study with a few teachers indicated the course helped teachers gain knowledge of math, pedagogy, and integration.

As examples of commercial courses, Abuhmaid (2011) discusses a training program initiated by the Jordanian education ministry where teachers were provided access to several training courses to improve ICT proficiency and pedagogy, including: Intel Teach to the Future, International Computer Driving License (ICDL), World Links, iEARN, and CADER. Most of the teachers took the ICDL course. A higher percentage of study participants at 76.5% reported developing computer skills compared to pedagogical skills at 50.4%. However, a large percentage of participants at 82.6% reported more student-centered learning after training. Teachers noted the disparate courses were fragmented and lacked a unifying set of national standards. Overbaugh and Lu (2008-2009) describe the use of six-week long, PBS Teacherline online courses to prepare teachers for technology integration. The courses involved an online community supported by discussion boards and synchronous meetings, assignments, and a final project or lesson plan. Local educators who were a part of participating school systems facilitated the courses, with the assumption they would better understand local standards and teaching environments.

In the literature on technology integration courses, a common method employed is the use of case studies and models. In one study of alternative licensure, pre-service teachers enrolled in a technology for educators course, Brantley-Dias, Kinuthia, Shoffner, deCastro, and Rigole (2007) reported case discussions helped participants "refine their technology integration ideas" and "challenge and confirm teacher beliefs" (p. 147). Greenhow, Dexter, and Hughes (2008) used the freely available, online Educational Technology Principle (eTIP) cases and found they helped pre- and in-service teachers to identify key issues, influencing factors, and make recommendations for technology use in specific contexts. In-service teachers were able to draw on their practical experience more so than preservice teachers. Adamy and Boulmetis (2005) studied the impact of training university faculty to model appropriate technology use across teacher education courses. They found individual faculty models and use of a portfolio tool impacted student confidence on six different ICT skills. West and Graham (2007) applied a "live modeling" approach to better prepare preservice teachers for technology integration. Preservice teachers were taught a K-12 lesson by their university teacher and took on the role of a K-12 student learning with technology. The approach helped most students acquire technology skills and develop a better understanding of integration strategies.

Short-Term Workshop, Institute, or Academy Approaches

Workshop training is a popular model for in-service teachers. The length, focus, and level of follow-up support varies widely. Brinkerhoff (2006) describes a technology academy model with teachers attending 15 full days of training and five days of in-service training, in each of two years. The extended time frame was purposefully planned to offset short duration barriers commonly associated with integration training, and stipends and instructional resources were provided to participants to offset motivational and equipment barriers. Teachers' principals and superintendents were required to endorse academy participation to offset administrative support barriers. Academy participants increased in their technical skills and confidence in using technology, and described some changes in teaching practice, although major changes to "student-centered and problem-based instruction" were not confirmed by survey data and were suggested to take more time to occur (i.e., 3-5 years) (p. 39).

Yost (2007) describes an extended three-year workshop model in Pennsylvania that provides for two full days of release time for teachers every year and required technology professional development. Year one focuses on personal productivity and teaching enhancement with a laptop and projector, year two focuses on better using cart-based laptops with students in the classroom on such tasks as Internet research, and year three focuses on integrating multimedia tools and software such as video cameras and iMovie. The first professional development session each year is offered in October or November, with 2-3 months for teachers to apply and test the new tools and strategies in their classroom before meeting again in February when they share lessons and experiences. Professional development sessions always include at least 90 minutes of hands-on practice with tools and strategies that are introduced by leading technology-using teachers. At the first "sharing" session in February of year one, teachers are introduced to a searchable server where they can find others' lessons and documents, and they are given time to upload and share their first lesson accordingly.

Ireh (2006) describes a workshop-based model that helped 18 North Carolina ESL teachers learn to integrate technology. Two weeks of intensive summer training was followed up with day-long workshops every other Saturday in fall and spring, with teachers paid a stipend for participation. A needs analysis was used to identify workshop topics that teachers could directly apply to develop lesson and resources (e.g., creating Webquests, using United Streaming resources, integrating literature circles, concept mapping, etc.). Participants were expected to develop, implement, and help their peers evaluate developed lessons and resources, with deadlines set for products. One unexpected finding was that teachers formed partners and new networks they could utilize for support and feedback.

Matzen and Edmunds (2007) describe a workshop-based model taught by the Centers for Quality Teaching and Learning (QTL) over seven days or 50 hours. Five workshop days are spent with teachers in the role of student, completing student-centered, constructivist activities. The activities model the integration of theory and practice with technology. Two workshop days are delivered as follow-up during the academic year. Teachers must attend the training in teams of three to five to build a small community within their school. In a study of the model, Matzen and Edmunds (2007) found teachers' integration was "correlated with their instructional beliefs," and more constructivist beliefs typically equated with more student-centered technology practices after training (p. 426). Most teachers made progress, however, in terms of student-centered practices as a result of modeling.

Keengwe and Onchwari (2009) describe an eight-week summer institute designed to help early childhood teachers better integrate technology. Three graduate credits were provided for completing the institute. Teachers were introduced to technology standards, online resources, and instructional tools. Each week, teachers developed an original technology project that made use of the resources and tools introduced (e.g., concept mapping applications, *Kidspiration*). Participants were required to compare and critique one another's work with the help of a rubric.

Miners (2009) describes the Teacher Leadership Project, initially funded by the Gates Foundation, and adopted by 18 states. The program involves a summer institute for training and follow-up online sessions, with modeling by lead teachers who have already attended the training. The TLP emphasizes student learning and how to use technology in support of "student thinking skills such as collaboration, problem solving, and creative thinking" (p. 37).

McPherson, Wizer, and Pierrel (2006) describe the Maryland Technology Academy Leadership program designed to produce lead technology-using teachers in schools throughout the state "who would provide technical support and professional development to other educators and contribute to strategic planning related to technology initiatives in their schools and districts" (p. 27). The program was delivered over three weeks in the summer and divided teachers into grade-level teams. Participants listened to daily lectures, attended technology strands, discussed integration in teams, and participated in labs with time for hands-on work. Follow-up sessions were scheduled throughout the year to continue teacher development, and participants were expected to participate in an online community and attend the state technology conference.

Coaching/Mentoring Approaches

Coaching or mentoring is another type of technology integration training approach that involves well-trained or experienced technology-using mentors supporting teachers less experienced with technology integration. Keengwe & Onchwari (2009) note coaches are commonly teachers "who are willing to share their knowledge of how to use technology in the classroom and their lesson plans for technology use with their peers" (p. 216). They suggest a teacher-coach be designated for each grade level, to help with troubleshooting technical issues, following up with individual teachers after workshops, and modeling technology uses and strategies. Plair (2008) discusses the concept of "knowledge brokering" to improve technology integration, where knowledge brokers take on coach-like roles. She suggests ideal brokers understand innovations in technology and instructional strategies, make themselves available for support in the classroom, and advocate for change by coordinating learning communities, social networking opportunities, and action research projects.

Jones, Fox, and Levin (2011) report on two coaching programs that led to increased student achievement and changes in the classroom environment. One program in California provided professional development and coaching to math teachers to better integrate whiteboards, student response, and digital content and tools. Another program in Washington based on the *Microsoft Peer Coaching* (MPC) curriculum, trained teacher-coaches in 75 school districts who then partnered or led teams in their school to share, team teach, and improve technology proficiency.

Barron, Dawson, and Yendol-Hoppey (2009) provide a concise summary of peer coaching literature, noting the process typically involves: "collaborative coaching cycles, rapport and trust, voluntary [participation], prolonged engagement and immediacy, shared goals [with a] clear focus, communication, reflection, and deep understanding" (pp. 4-6). The same authors conducted an evaluation of the MPC curriculum in Florida, involving the training of peer coaches in several districts. Program participants cited concerns over lack of time and lack of technology resources in some schools to effectively implement coaching, and some coaches believed traditional workshops would be more effective to introduce integration examples.

Halter and Finch (2011) describe the Classrooms for the Future (CFF) program in Pennsylvania, which provided technology funds, professional development, and a full-time instructional technology coach for selected schools. The authors note the coach initially helped locate resources and provide training, but the role has evolved to include co-planning, co-teaching, and embedded training in the classroom.

Lowther, Inan, Strahl, and Ross (2008) studied the implementation of Tennessee's EdTech Launch (TnETL) program that employed full-time technology coaches in 26 schools to prepare teachers for technology integration. Specifically, coaches were to provide professional development that would prepare teachers "to create student-centered environments that engage students in critical thinking and use of computers as tools in order to increase learning and performance" (p. 198). Results show increased teacher technology confidence, and better use of computers as tools for project-based and research-oriented learning compared to control classes.

Faulder (2011) provides a thorough summary of training programs for ICT integration, utilizing the background to design a new model of professional development involving teacher mentors or coaches in support of less knowledgeable peer teachers. The first phase of the program involves surveying teachers to determine how well the school culture supports ICT integration, sharing this information with school leaders to ensure support for change, and selecting teacher mentors. The second phase involves training teacher mentors during summer seminars and meetings during the school year on mentoring, usage of common productivity software, and usage of ICT tools in support of constructivist pedagogy. A Web resource is also included in phase two as a repository for developed classroom lessons and a place to begin building the instructional support network. Phase three involves teacher mentors working with "limited-use teachers" to address their needs and slowly introduce them to ICT use in the context of completing professional tasks (p. 116). Phase four involves additional mentoring, but in the context of collaboratively developing lessons with support.

McCombs (2010) also describes a train the trainer model in North Carolina, where five or six technology-using teachers at selected schools were chosen to receive initial technology training at a rapid pace. Lead teachers were then tapped to train other teachers in the summer, modeling new skills. Training included time to troubleshoot the networking of common tools such as cameras and whiteboards to prevent minor technical problems that might arise, and participants discussed how to support curricular goals such as critical thinking with technology. McCombs (2010) also discusses collaborations between expert and novice technology-using teachers which aided in integration, including joint units and shared lessons.

Kopcha (2010) outlines a systems model of mentor-supported technology integration, where mentors help teachers progress through four stages of setup, preparation, curricular focus, and communities of practice. In each stage, the focus of the mentor is different. For example, in the setup stage, the mentor primarily focuses on troubleshooting technology problems and helping the teacher plan a system of management for technology use in the classroom. As the teachers progress through the four stages, the mentor's focus also changes. The model provides excellent practical advice for those in the mentor role, in ways to reduce common barriers to integration.

Sahin and Toy (2009) also describe a transformational coaching program in which international student teachers from Turkey were partnered with a mentor teaching in the United States for six weeks. Interns started out by observing, then assisted the mentor teacher, and then took over teaching responsibilities for certain class components. It was suggested pre-service teachers with at least some background knowledge of student-centered teaching might be better prepared to enter into the mentee role. Wilder, Ferris, and An (2010) describe another international program in which American pre-service teachers mentored Namibian teachers through a technology integration activity, with pre-service teachers gaining a better understanding of the digital divide and potential barriers to technology integration.

Several coaching programs involve pre-service and in-service teachers collaborating, with the expert technology-using mentor being the pre-service teacher in some cases and the in-service teacher in other cases. Denton et al. (2005) describe the *Technology Mentor Fellowship Program*, through which technology-using pre-service teachers (i.e., the experts) were paired with in-service teachers and university faculty to support technology integration. The undergraduate fellows worked collaboratively with teachers and faculty to "develop learning objects across a wide range of content areas" (p. 8). Voithofer (2005) describes a similar model in which pre-service teachers supported in-service teachers with technology integration as a type of service learning project. In-service teachers were able to provide an authentic context to situate the work of pre-service teachers in an educational technology course, while pre-service teachers were able to develop materials to support the needs of in-service teachers. The partnership was suggested to provide in-service teachers with increased confidence in using technology with students and new integration ideas. Wright and Wilson (2007) describe another mentoring project in Alabama where ten master technology teachers were selected from an in-service pool, trained over the summer, and then partnered with pre-service teachers on joint projects. Joint planning was effective in preparing pre-service teachers for future roles.

An emerging area of coaching involves some form of blended learning in which an online teacher partners with a classroom teacher to share instructional duties. Baskerville (2011) describes one such arts e-learning program in New Zealand in which an online music teacher partnered with a classroom-based primary teacher. While expanding opportunities for students, the partnership also provided learning opportunities for teachers, as they were able to "exchange ideas, explore new ideas, discuss and gather evidence of the changes (successful or not) and reflect on teaching practice" (p. 129).

Learning Community Approaches

In their summary of promising technology professional development options for teachers, Jones, Fox, and Levin

(2011) highlight "professional learning communities and communities of practice" noting communities commonly address shared community interests, encourage collaborative activities and discussions, and produce resources representative of the shared interest (p. 10). The authors highlight two sample learning communities that have been tied to gains in student achievement. One math-focused community in Massachusetts trained teachers on appropriate technologies through an online course, and then encouraged online and in-person meetings to prepare for further dissemination of knowledge to peer teachers not in the community. Another community in New Jersey focused on math also received professional development, access to instructional coaches, and community discussions.

Communities of practice (COP) involve a small group engaged in a common practice. The COP model was used to design a graduate-level instructional technology program at Northern Illinois University with cohorts of educators (i.e., teachers, administrators, professionals) enrolled in an 18-24 month blended learning program (Cowan, 2012). Each cohort engages in learning new applications, discussing how applications can be integrated into instruction, and designing curriculum and staff development. Participants reported positive experiences in the program, with many participating in alumni networks and returning to teach for the program. Macdonald (2008) promotes the idea of communities of practice involving both teachers and university researchers, applying design-based research methodology to study ICT integration. Since the processes of design-based research and integration are both iterative, they provide opportunities for testing and reflection cycles that can be used to improve practice over time.

Hawley et al. (2003) describe the cohort model adopted at UC-Riverside to prepare teachers for the new state technology credential. Triads were formed between a pre-service teacher, their faculty supervisor, and a K-12 teacher. The trio collaboratively designed a unit of instruction using technology, and implemented the instruction.

Martin and Vallance (2008) describe the use of synchronous networking technology in an undergraduate, pre-service teacher course on computer applications in language and literature. The course utilized the online *iStorm* application that allows for co-document editing as well as a chat window to discuss the editing. Four collaborative tasks were designed and studied (e.g., co-editing a report outline). The authors found "synchronous networking technology was able to bring about a heightened awareness of and confidence in applying more open-ended or constructivist pedagogy, especially when used to facilitate trainee teachers examination of and reflection on their tacit pedagogical assumptions and expectations" (p. 51). A primary difference between this study and others is using the technology not to acquire technical skill but to develop pedagogical awareness about potential ICT use.

Hughes, Kerr, and Ooms (2005) outline a technology integration program centered on a "content-focused technology inquiry group" among five middle school teachers, one university faculty member, and three university students (p. 367). The group met each month for an hour to discuss integrating technology in their content areas, and university partners worked with individuals or smaller groups in between meetings. Individual teachers worked on their own inquiries and investigated how different technologies could solve learning problems.

In the spirit of a community of practice, Ehman and Bonk (2002) describe Indiana University's Teacher Institute for Curriculum Knowledge about Integration of Technology (TICKIT). The program recruits cohorts of five teachers from selected schools that have leadership commitment, appropriate technical infrastructure, and some professional development funds to pay for a small portion of teacher participation in university courses (with the remainder paid from university grants). Teachers enroll in a three-hour blended graduate course during the fall and spring semesters, receiving some instruction live at the university or school sites, and some instruction online. TICKIT is supported by asynchronous online discussions, an orientation workshop at the beginning of fall semester and closing workshops at the end of each semester on the university campus, and at least one workshop at each school focused on the needs of the cohort. Teachers work to complete individual "curriculum infusion" projects that require action research and documentation of support materials designed, student work, assessment data, and reflections on lessons learned and revisions required. Teachers are required to share their action research reports with the graduate course instructor for a grade, with both TICKIT and school colleagues, and with other educators at the state computer conference. The program also required cohorts to plan an action research project involving their larger school staff in integration.

Professional learning communities can involve teachers working collaboratively in teams to continuously study and improve student learning. Cifuentes, Maxwell, and Bulu (2011) investigated the formation and evolution of learning communities in five schools over a two-year period. Each school team included "five teachers, one technology coach who was also a teacher, one administrator, and one teacher from a school in the mentor district where technology was being masterfully integrated" (p. 65). The STAR program included multiple strategies, including: meetings during the school year, two 5-day summer workshops, and targeted workshops which were well received when the focus remained on applying technologies to pedagogy. Findings showed teachers moved up a stages of adoption scale each year with increased technology integration, and teachers moved from a focus on classroom management in year one to a focus on student-centered learning in year two. Student engagement in classrooms also increased.

Phelps and Graham (2008) describe the Technology Together program in Australia, focused on mentoring teachers through a metacognitive process of reflection on action and management or implementation of more appropriate strategies. Entire schools were tasked with implementing action research that applied metacognitive reflecting with the support of mentors. Findings suggest teachers needed to be pushed to set high-impact, risky goals, and strategies such as modeling and discussing needs can help improve teacher attitudes and encourage innovation.

Duran, Brunvand, and Fossum (2009) also describe a comprehensive learning community approach in Michigan, involving pre-service student science teachers, in-service teachers, college of arts and sciences faculty, college of education faculty in educational technology, and university student teacher supervisors/mentors. Cohorts participated in capacity-building workshops on technology tools (i.e., telecommunication, productivity, and multimedia), additional technology seminars, as well as three learning circles during the academic year to co-design and reflect on projects. Participants increased in technology confidence/comfort and competence/frequency of use, and demonstrated improvements in using tools in support of science instruction particularly in terms of student research, presentation, and artifact creation.

Product and Assessment Approaches

Another technique institutions have used to promote better technology integration is assessment of teacher technology competencies and products. Graham, Tripp, and Wentworth (2009) report on a pre-service teacher program that assesses teacher work samples (TWS) or culminating unit plans developed and implemented in field experiences. In the first year of analysis, TWS primarily focused on teacher uses of technology, while only one-third of TWS actively involved students in uses of technology. Field instructors and in-service teachers communicated expectations to the pre-service teachers that did not meet the loftier goals of technology-proficient faculty. Further training of field instructors was undertaken as well as refinement of written criteria. In the second year of analyzing TWS, student uses of technology increased from 33% to 59% with a wider range of technologies integrated.

Hawley et al. (2003) describe the portfolio approach taken at the University of San Francisco. Pre-service teachers produced culminating electronic portfolios that required the skills necessary to meet a new state technology credential. The portfolio development process stretched over at least three semesters, starting with a "boot camp" to introduce basic technology skills, a two-credit hour course covering technology integration, a portfolio review during the semester of student teaching with feedback on missing elements and opportunities for revision, and a one-credit hour course during which candidates finalize their portfolios with examples from their teaching experience.

What Should Teachers be Learning in Technology Integration Training: Competencies and Models of Teacher Understanding

This section provides an overview of technology integration competencies or concepts that teachers should be learning about, as recommended in the literature. Further, a summary of selected integration models is provided that are recommended to guide teacher practice.

Knowledge Gaps

Professional development and training for technology integration is divergent and focuses on many different topics. Often mentioned are personal productivity skills to increase teacher comfort with technology (Cifuentes et al., 2011; Gronseth et al., 2010) and technical skills to help teachers with technology setup and troubleshooting (Kopcha, 2010). Studies have shown preservice teachers need additional experiences in creating online content such as Web sites, wikis, blogs, and e-portfolios (Kumar & Vigil, 2011). Studies have also shown teachers may have informal experiences with social networking and collaborative Web 2.0 tools such as Google Docs, but these experiences don't always translate to classroom practice where such tools tend to be applied less (Kumar & Vigil, 2011). The authors recommend more exposure to such tools in preservice teacher education, since teaching beliefs are shaped by faculty models.

In those learning environments where student access to technology is high, including one-to-one computing environments, Blind (2011-2012) describe new strategies that have been enabled by the technologies. For example, teachers are better able to support new modes of student-student communication and student-teacher communication, and thus professional development on tools to support that communication is warranted (e.g., discussion boards, chat, concept mapping, online bulletin boards, polling).

Wetzel, Foulger, and Williams (2008-2009) lament the impossibility of teaching every possible Web 2.0 tool in a technology integration course, and suggest the solution is to prepare teachers to be lifelong learners capable of finding and putting to use new tools throughout their long careers. They introduced a constructivist "mini-teach" project where students worked in small teams to research and master a new tool, describe its potential uses in classrooms, and teach their peers to use it. Work products were archived on an ever-developing wiki that course alumni and future participants alike could use and build on.

It has been suggested that teachers receive an introduction to available digital resources through professional development (Cifuentes et al., 2011), as well as an understanding of how to evaluate and choose the best resources with practice making curricular connections to resources (Kumar & Vigil, 2011). Several authors report that teachers need to focus on learning or curricular goals first, and integrate technologies in support of those goals (Kopcha, 2010). In their survey of faculty responsible for educational technology experiences in 407 U.S. institutions, Gronseth et al. (2010) found faculty "indicated that the most important topic addressed in their teacher education program was how to use technology to support curricular goals" (p. 33). Beaver and Moore (2004) recommend professional development focus less on technical aspects and more on "hierarchies and methodologies" (e.g., Bloom's taxonomy) such as using technology to help students "compare and contrast, synthesize, or apply" (p. 42). Otherwise, teachers might think using technology to deliver instruction constitutes integration, when no student skills are being supported at all. The authors recommend teachers learn to design lessons that foster higher-order thinking. Blind (2011-2012) recommend teachers in technology-rich schools learn about curricular models that will support local and global collaborations as well as social tools used in those projects (e.g., Twitter).

Davies (2011) notes teachers should learn how to "apply technology to authentic situations" since effectiveness is highly context-dependent (p. 49). Greenhow, Dexter, and Hughes (2008) found in-service teachers were better able to apply familiar classroom and school context factors to integration decisions in case studies, compared to less experienced preservice teachers. They note preservice teachers "may need more practice and scaffolding in explaining and justifying their instructional designs, if they are to be better prepared for implementing technology" (p. 20). Similarly, in a longitudinal study of social studies preservice teachers, Wright and Wilson (2005-2006) found teachers needed a range of diverse experiences to help them think of creative solutions to overcome technology barriers.

Shane and Wojnowski (2007) describe the Technology Integration Enhancing Science (TIES) program for North Carolina science teachers. The program focused on using technology to support authentic inquiry-oriented projects, and introduced teachers to available Internet and content resources. Opportunities were provided to share experiences among program and non-program participants, as well as a learning community. Participants developed more student-centered teaching philosophies and moved up on a levels of use scale, but change reportedly took from three to four years with the need for ongoing support.

Blind (2011) note teacher leaders in technology-rich schools could use professional development on strategies to support shared decision making, such as surveying students with online tools or collecting ideas from peer teachers via wikis or polls. Teacher leaders could also use training on specific strategies such as needs assessing and asset mapping to help define both a school's needs and its available community resources.

Several authors have indicated teachers need a better understanding of managing technology-infused systems and classrooms (Cifuentes et al., 2011; Kopcha, 2010). Pusey and Sadera (2011-2012) found 318 preservice teachers were largely unprepared to model or teach cyberethics, cybersafety, and cybersecurity (C3) topics, representing another knowledge gap.

Models to Guide Teacher Understanding

A number of models have been proposed to guide teacher understanding of technology integration, including usage- and activity-based models, knowledge-based models, conditions-based models, process-based models, theoretical models, and metaphorical models.

It has been recommended that technology professional development be grounded in usage-based models that specify different categories of technology use (e.g., for presenting, differentiating, assessing, student projects, etc.). In their survey of more than 2800 teachers in 22 Massachusetts school districts, Russell, Bebell, O'Dwyer, and O'Connor (2003) found teachers commonly engage in six uses of technology: "to deliver instruction, to prepare for instruction, to accommodate [differentiate] instruction, to communicate with others in and out of the school, and to direct students to use technology for specific instructional purposes" (p. 307). The authors suggest these categories might provide a framework for introducing teachers to applications and technologies that can be used in support of each category.

As a sub-category of the usage-based model, it has also been recommended that technology professional development be grounded in activity-based models that specify technology use around different classroom activities or strategies. For example, Hammond (2007) recommends an activity or task-oriented framework that focuses on training teachers to use technology around "common classroom activities ... such as collaboration, research, presentation, and composition" (p. 153). Further, Harris, Mishra, and Koehler (2009) present an activity-based model of 42 common social studies activities (e.g., view images, debate, develop historical chains) aligned with technologies that could support them. In a related study of professional development around activity types, Harris and Hofer (2011) found teachers' alignments of technologies and activities were intentional and varied as well as focused on student-centered learning goals.

It has also been recommended that technology professional development be grounded in knowledge-based models which specify the type of understanding teachers should develop and possess. For example, Guzman and Nussbaum (2009) suggest there are six competency domains around technology integration: basic competencies; understanding use in support of curriculum, specific teaching methods, and collaboration and communication; understanding evaluation to inform and improve technological practice; and reflecting on personal practice and attitudes. Further, Summerville and Reid-Griffin (2008) created modules for a pre-service teacher technology integration course that were aligned with common elements of an instructional design model, with teachers learning to analyze content, plan lessons, consider government mandates and standards in their designs, evaluate media, document student assessment data, and more.

Considerable attention has been paid in technology integration literature to Shulman's (1986) concept of pedagogical content knowledge (PCK), with many authors expanding on the idea to introduce new frameworks representing what technology-using teachers should know and be able to do (Ertmer & Ottenbreit-Leftwich, 2010; Wetzel, Foulger, & Williams, 2008-2009). PCK itself represents a teacher's understanding of not just content being taught, but also of pedagogical strategies that can be used to best teach that content (e.g., through concept maps, cases, lecture, discussions, etc.). Mishra and Koehler (2006) expanded on the notion of PCK with a more developed, overlapping framework consisting of three knowledge frames in pedagogical-content knowledge (PCK), technological-content knowledge (TCK), and technological-pedagogical knowledge (TPK), which combine to form technological pedagogical content knowledge (TPACK) (Mishra & Koehler, 2006). Wetzel, Foulger, and Williams (2008-2009) applied the TPACK model to frame a project-based lesson in a technology course for preservice teachers, such that teachers not only learned about new technologies, but about pedagogy appropriate in a specific content area. The authors note the importance of reflecting with teachers "to make explicit the TPACK framework and how they learned content, pedagogy, and technology skills" (p. 70). Working off of Shulman's PCK notion, in a similar way to Mishra and Koehler (2006), Brantley-Dias et al. (2007) presented a five-dimension model known as PTICK or pedagogical technology integration content knowledge. PTICK includes PCK as well as an understanding of technical operations, technology integration principles, how to reflect, and how to operate in and support professional communities of practice. Koh and Divaharan (2011) created a three-phase training approach to develop TPACK in teachers focusing on proficiency, modeling appropriate pedagogy, and teacher application of pedagogy. In work with 74 teachers, the authors report technological knowledge and TPK were developed, but additional modeling and sharing were required to fully develop content connections or TCK.

Petko (2012) outlines the three components of a conditions-based model that specifies the conditions under which technology integration will be more likely to occur based on research into common barriers. The "will, skill, tool" model suggests technology integration is more likely when teachers have the will or positive attitudes toward technology use, have the skills or technology proficiency, and have the tools or access to technologies.

Process-based models ground some technology professional development by specifying cycles teachers can work through to develop greater competency. Chien, Chang, Yeh, and Chang (2012) advocate the use of the MAGDAIRE model which represents a four-phase process of modeled analysis, guided development, articulated implementation, and reflected evaluation. Preservice teachers working through the model improved in technology competency around programming in Flash and matured in their perceptions of technology affordances. Lubin and Ge (2012) discuss the Learning Environments Approaching Professional Situations (LEAPS) model in which 60 pre-service teachers in a university-based educational technology course worked in small groups to solve open-ended problems that required usage of various office technologies (e.g., planning a parent-teacher conference). Findings show the approach helped teachers learned to reflect on problem solving around instructional technology. Summerville and Reid-Griffin (2008) present a cyclical instructional design model used to design eight modules for a pre-service teacher technology integration course.

Technology integration has also been grounded in theoretical models such as Legitimation Code Theory (LCT) (Howard and Maton, 2011) or Socio-Materiality (Johri, 2011). The latter of which emphasizes the importance in considering both the social aspects of technology use and the material design aspects of technology production simultaneously when planning technology-enhanced learning environments. In one study, the authors describe how Engineering students leveraged the material or representational aspect of different tools to represent sketches and data, and intertwined the social or relational aspects of different tools to collaborate and discuss the same. It was important for the learning environment to align both social and material elements.

Basham, Perry, and Meyer (2011) advocate the use of a metaphorical model called "digital backpacks" to help teachers plan technology-enhanced lessons for problem- and project-based learning. Backpacks include some "foundational technology" like an iPad or laptop, as well as "modular technology" to meet specific goals such as camcorders or audio recorders, and finally "instructional support materials" such as worksheets, videos, and apps, to structure and guide. The metaphor of a backpack could be used to help novice technology-using teachers think about combinations of technology and support materials that can enable a specific lesson.

Influencing Factors on Technology Integration Practice

This section provides a brief introduction to factors known to influence technology integration practice. Leadership is discussed first, as it is thought to directly affect external and internal factors discussed in two subsequent sections.

Technology Leadership

Leadership is perhaps the most critical external factor discussed in the literature that can influence technology integration for the better or worse. ISTE provides technology standards for administrators (NETS-Admin) that can be used to define roles for technology-supporting leaders (Larson, Miller, & Ribble, 2009-2010). Among these roles, supportive school leaders communicate a vision for technology use and include teachers and other stakeholders in the process of defining a school's vision (Ertmer & Ottenbreit-Leftwich, 2010; Hsu & Sharma, 2008; Larson, Miller, & Ribble, 2009-2010). To help with establishing a vision, Duncan (2011) recommends schools utilize the National Educational Technology Standards (NETS) developed by ISTE. Larson, Miller, and Ribble (2009-2010) recommend school leaders employ needs assessment to understand "gaps in their technology needs related to the shared vision" (p. 14).

As one part of visioning, school technology leaders advocate for change by communicating instructional expectations or goals via technology plans and sometimes requiring technology use as a key part of instruction (Keengwe & Onchwari, 2009; Richard, 2007). Anthony and Clark (2011) reported one dilemma of practice faced by teachers in a laptop program was defining the role of technology (i.e., should they use technology as a response to some vision or goal, as a response to some administrative rule such as posting lessons online, or as a tool to improve instruction). The study illustrates the confusion that can result when a vision is not articulated.

Staples, Pugach, and Himes (2005) compared three urban elementary schools and found one scaffold that impacted technology integration was how a principal articulated the alignment of technology use with the school's mission or curriculum. Principals articulated alignments differently in terms of a broad mission (e.g., project-based learning), improving instruction (e.g., writing, literacy, research), or more in relation to test-based achievement scores than any curricular area. It was recommended principals align technology use to the curriculum and specific content areas and "resist the temptation to acquire hardware and software decontextualized from a specific curricular goal" (p. 302).

Strong leaders secure resources, plan for professional development, and provide time for teacher team meetings or communities of practice (Abuhmaid, 2011; Cviko, McKenney, & Voogt, 2012; Ertmer & Ottenbreit-Leftwich, 2010; Faulder, 2011; Keengwe & Onchwari, 2009; Larson, Miller, and Ribble, 2009-2010; Richard, 2007). Technology leaders also participate in technology professional development or courses to know what is possible in the classroom, and they model appropriate practice for teachers (Hsu & Sharma, 2008; Miners, 2009; Richard, 2007). Shinsky and Stevens (2011) recommend educational leaders learn to use a variety of Web 2.0 applications in support of digital collaboration (e.g., Google Docs, wikis). McCombs (2010) refers to a leadership training program where principals and district technology directors "learned about becoming change agents, facilitating collaborative planning, implementing flexible scheduling, using alternative assessments to evaluate both teachers and student work, and identifying Web 2.0 tools for administrative and instructional tasks" (p. 11).

External Factors

Many authors have discussed the role access to technology resources can play in either promoting integration under ideal circumstances or limiting integration when teachers can't access computers, software, or the Internet (Brinkerhoff, 2006; Donnelly, McGarr, & O'Reilly, 2011; Lowther, Inan, Strahl, & Ross, 2008; Richard, 2007). In some cases, schools have no resources, while in many cases, schools have too few resources for teachers to reliably schedule computer labs or laptop carts. If teachers cannot depend on resources being available, then obviously they cannot plan to integrate them into the curriculum. In a survey of 126 teachers by An & Reigeluth (2011-2012), 57% believed lack of technology was a barrier to integration. This factor is highly variable and site-dependent.

Another external factor known to influence technology integration is access to and reliability of technical resources and infrastructures (Duncan, 2011; Faulder, 2011; Hutchison, 2012; Petko, 2012; Tezci, 2011; Wachira & Keengwe, 2011; Wright & Wilson, 2011). Inan and Lowther (2010) found computer availability was one of three variables that directly effected teacher technology integration. Petko (2012) also found computer availability was one factor explaining teacher usage of software and Web applications. Tezci (2011) found computer ownership and access to the Internet were factors that primary school teachers in Turkey associated with a facilitative school culture for integration ICT. It is important to note that simply providing more computers will probably not result in increased integration, as evidenced in a study of one school of education which distributed laptops to all faculty and preservice teachers to remove barriers of access and infrastructure (Vermillion, Young, & Hannafin, 2007). Additional factors such as lack of common vision, expectations for use, pedagogical understanding, and training, led to uneven integration.

Access to human supports (e.g., technical, instructional coaches) is widely held to influence technology integration (Brinkerhoff, 2006; Duran, Brunvand, & Fossum, 2009; Faulder, 2011; Hutchison, 2012; Keengwe & Onchwari, 2009; Lowther, Inan, Strahl, & Ross, 2008; Richard, 2007; Teo, 2011; Wachira & Keengwe, 2011). Technology facilitators and technical support staff are common in most states, but funding is piecemeal. When only one of the two positions can be hired, problems occur with holes in instructional or technical support, or an instructional position can become saddled with technical support with less time to work with faculty on curriculum integration. Studies have shown positions like technology coordinators can impact on student learning and technology skills (Lesisko, Wright, & O'Hearn, 2010).

Other external factors known to influence technology integration include access to shared instructional resources, data, and content, as well as access to ideas from peers, teacher leaders, or experts in online communities (Duncan, 2011; Duran, Brunvand, & Fossum, 2009; Faulder, 2011; Hutchison, 2012; Lowther, Inan, Strahl, & Ross, 2008; Macdonald, 2008; Staples, Pugach, & Himes, 2005; Wright & Wilson, 2005-2006; Wright & Wilson, 2011).

School policy can influence technology integration. Robinson, Brown, and Green (2007) discuss information technology policies and measures taken to safeguard student accounts, privacy, and persons, as well as avoid issues with copyright and liability. Examples are given of teachers who could not teach with technology in legitimate ways, due to restrictive information technology practices. The recommendation is to find a proper balance between protection and open access to tools and resources.

Access to ongoing professional development can influence technology integration (Abuhmaid, 2011; An & Reigeluth, 2011-2012; Brinkerhoff, 2006; Faulder, 2011; Gerard, Varma, Corliss, & Linn, 2011; Wright & Wilson, 2011). Richard (2007) recommends beginning any professional development program with a needs assessment to inventory teacher skills. In a survey of

126 teachers by An & Reigeluth (2011-2012), many respondents indicated professional development needs to be more targeted to specific subject areas with examples they can readily apply, it needs to focus on a few concepts at one time with opportunities to practice, and it needs to focus on technologies or software they actually have in their schools. Communities of practice who share strategies were also recommended as supplements to traditional professional development. Richard (2007) describes one school system's professional development approach that targets five key groups: model teachers, media specialists, administrators, instructional television personnel, and network personnel. The "five star groups" provide a core of technology users who other teachers can turn to with questions (p. 25). Group members receive grant-funded equipment incentives for completing different levels of proficiency (e.g., flash drives, scanners, digital cameras). Abuhmaid (2011) reported several factors that impacted on the success of course-based, ICT professional development in Jordan, including not providing enough time and computers to practice newly learned skills, not enough mentors to follow-up with teachers after training, and not scheduling training during the work day so it would not interfere with teachers' home lives. Gerard, Varma, Corliss, and Linn (2011) summarized 43 studies of professional development for inquiry-based science, noting the most successful programs were extended beyond one year with a focus on integration and inquiry, while less successful programs were of short duration and only introduced a new tool or technology. In shorter-term programs, teachers naturally get tied up in "technical and instructional challenges" as they struggle to integrate a tool for the first time (e.g., securing and setting up equipment) (p. 424).

Finally, providing teachers with adequate time for planning and preparation in technology-intensive learning environments has been shown to influence integration (An & Reigeluth, 2011-2012; Brinkerhoff, 2006; Duran, Brunvand, & Fossum, 2009; Faulder, 2011; Hutchison, 2012; Keengwe & Onchwari, 2009; Wachira & Keengwe, 2011). In a survey of 126 teachers by An & Reigeluth (2011-2012), about 57% perceived lack of time as a barrier.

Internal/Personal Factors

Many articles discuss the implications teacher technological knowledge and preparedness (Faulder, 2011; Hutchison, 2012; Kanaya, Light, & McMillan-Culp, 2005; Keengwe & Onchwari, 2009; Lowther, Inan, Strahl, & Ross, 2008; Petko, 2012; Wachira & Keengwe, 2011). Better knowledge or preparedness has been correlated with and used to significantly predict or explain technology usage (Hsu, 2010; Inan & Lowther, 2010; Kanaya, Light, & McMillian-Culp, 2005), and better knowledge has been associated with increased self-efficacy or confidence that has likewise been associated with integration performance (Adamy & Boulmetis, 2005; Brinkerhoff, 2006; Cullen & Greene, 2011; Cviko, McKenney, & Voogt, 2012). Abbitt (2011) found several TPACK variables (TPCK, TPK, TCK, and TK) to be related to teachers' self-efficacy beliefs about technology integration, and additional variables (TPK, TK, PCK, PK) could be used to predict teachers' self-efficacy beliefs. The study illustrates the importance of properly preparing teachers, as teachers well-trained in technology will likely develop higher self-efficacy or confidence to integrate technology. In a survey of teachers in Nova Scotia, Moore-Hayes (2011) found no significant differences in self-efficacy between pre-service and in-service teachers, but found both groups possessed "less than adequate" self-efficacy in terms of knowledge of evaluating software, integrating technology, knowing when and why to integrate technology, and using assistive technologies. The teachers reported they would be better prepared if they had practicum experiences in technology-enhanced classrooms, mentoring by expert technology-using teachers, and opportunities to take online classes.

Self-efficacy based on knowledge may vary considerably by sample, as only 35% of 126 teachers in a survey conducted by An & Reigeluth (2011-2012) reported lack of knowledge about "learner-centered instruction and ways to integrate technology into learner-centered instruction" was a barrier to integration (p. 59). Others suggest, however, that teacher fear and anxiety in terms of knowing less than students, losing control of classrooms, or being able to keep up with new technologies, can impact on one's willingness to integrate (Brinkerhoff, 2006; Faulder, 2011). Overbaugh and Lu (2008-2009) found a technology training program was able to reduce "task-based management concern" among teachers, but the concerns returned to their original levels possibly as a result of environmental barriers such as limited access to technology (p. 52). The authors also found younger teachers had significantly greater self- and task-based concerns in regards to technology integration, and they suggested these teachers might benefit "more than others from continued professional development opportunities" (p. 53).

Another internal factor known to influence integration is teacher pedagogical knowledge (Ertmer & Ottenbreit-Leftwich, 2010; Faulder, 2011; Lowther, Inan, Strahl, & Ross, 2008) and teacher understanding of curricular integration (Keengwe & Onchwari, 2009; Okojie, Olinzock, & Okojie-Boulder, 2006). Petko (2012) found teachers were more likely to employ software and Web-based applications when they held constructivist beliefs and possessed the attitude that "computers improve student learning" (p. 1351). Russell, Bebell, O'Dwyer, and O'Connor (2003) found teachers tended to use technology more for teacher-centered activities (e.g., lesson preparation, communication) than for "assigning learning activities that require the use of technology" (p. 297). Likewise, Sangra and Gonzalez-Sanmamed (2010) found teachers tended to view ICT as useful for gaining attention, student response, and transmitting information, more so than for interaction and communication, although teachers in level four schools with better access to technology reflected on ICT more favorably. In a study of Chinese teachers, Sang, Valcke, van Braak, and Zhu (2011) found teachers fell into these same two categories, and any student-centered uses of ICT were directly related to teacher technology beliefs and support and indirectly related to pedagogical beliefs and attitudes. An & Reigeluth (2011-2012) caution teachers may hold a learner-centered philosophy but implement teacher-centered classrooms. Teachers responding to their survey desired more training on specific learner-centered instructional strategies to overcome the dichotomy. Liu (2011) also found in a survey of 1139 Taiwanese elementary teachers that learner-centered beliefs in 79.3% of the sample only translated to constructivist teaching by 28.2%. The author suggests these teachers had concerns over student achievement and had associated teacher-centered practice with higher scores.

With regard to teacher technological and pedagogical knowledge, many authors have noted teacher knowledge and practice are widely divergent based on quality of training or years of experience. Attempts have been made to categorize levels of technology integration to show where teachers lie on a continuum of very basic, teacher-centered integration, to more expert, student-centered integration. Knowing where teachers like on a continuum can be a useful guide to target professional development efforts at moving teachers from novice to expert stages of use (Donnelly, McGarr, & O'Reilly, 2011; Ireh, 2006). Most agree stages are not fixed, but it takes training, effort, and time to move up. The following is a list of some teacher development stages noted in technology integration literature:

- entry, adoption, adaptation, appropriation, invention (Dwyer, Ringstaff, & Sandholtz, 1991)
- survival, mastery, impact, innovation (Mandinach & Cline, 1992)
- familiarization, utilization, integration, reorientation, evolution (Hooper & Rieber, 1999)
- nonuse, orientation, preparation, mechanical, routine, refinement, integration, renewal (levels of use) (Shane & Wojnowski, 2007)
- "self-based concerns (awareness, information, personal), task-based concern (management), and impact-based concerns (consequence, collaboration, refocusing)" (concerns-based adoption model) (Overbaugh & Lu, 2008-2009, p. 46)
- setup, preparation, curricular focus, community of practice (Kopcha, 2010)
- awareness, praxis (training), phronesis (competence) (Davies, 2011)
- contented traditionalist (fatalistic focus on extrinsic factors), selective adopter (adopt only technologies that can help students assess well), inadvertent user (use technologies based on external pressure and inadvertently move toward student-centered learning), creative adapter (focus on student-centered approaches in support of greater learning) (Donnelly, McGarr, & O'Reilly, 2011)
- level 1 school (unmotivated teachers, limited ICT use for educational purposes, computers but no network), level 2 school (no school plan for technology, a computer lab available but infrequently used), level 3 school (several computer labs, some classroom-based computers, networked, ICT mentioned in school plans), level 4 school (sound infrastructure and network, technical support, vision for ICT use in the classroom) (Sangra & Gonzalez-Sanmamed, 2010)

Positive attitudes toward technology (Cviko, McKenney, & Voogt, 2012; Faulder, 2011; Ertmer & Ottenbreit-Leftwich, 2010) and teacher motivation and determination (Cullen & Greene, 2011; Duran, Brunvand, & Fossum, 2009; Faulder, 2005) are two related variables commonly associated with technology integration practice. Positive technology attitudes have been found to predict "both intrinsic and extrinsic motivation to use technology" and uses of technology (Cullen & Greene, 2011, p. 42; Inan & Lowther, 2010; Kanaya, Light, & McMillan-Culp, 2005; Teo, 2011). Scales have been developed to rate a teacher's technological beliefs or attitudes, or whether teachers believe learning can be improved or made more efficient by technology, and whether it's worth the effort to learn about new technologies (Brush, Glazewski, & Hew, 2008). In a survey of 126 teachers by An and Reigeluth (2011-2012), most participants agreed with such beliefs. Russell, Bebell, O'Dwyer, and O'Connor (2003) report "teacher beliefs about the importance of technology for teaching was the strongest predictor of the frequency with which technology is used for a given purpose" (p. 302). Given a relationship was also noted between exposure and improved beliefs, the authors recommend exposing teachers to "uses of technologies" during training (p. 303). Kenny and McDaniel (2011) studied teacher attitudes toward educational games, noting "an increase in positive attitudes towards playing games after participants actually played," suggesting again that exposure to technology during training can be used to improve attitudes (p. 208). They note that teachers "did not yet fully understand or appreciate the potential of games due to their unfamiliarity with them" (p. 210). Abuhmaid (2011) found course-based ICT training helped teachers understand the benefits of ICT, and they subsequently changed instructional strategies and made improvements in student-centered teaching. Kim and Keller (2011) found it was also possible to increase pre-service teacher attitudes toward technology by sending motivational and volitional email messages during a course on educational technology. After an audience analysis, messages were tailored to individuals to address issues with motivation, goals and intentions, and control.

As shown, failure to tend to external factors such as professional development can worsen internal/personal factors such as technological and pedagogical knowledge and subsequently self-efficacy, attitudes, and motivation. A needs assessment is a good way to determine the presence or status of external and internal/personal factors prior to beginning a technology integration training program (Kopcha, 2010; Richard, 2007).

Targeting Comprehensive Reform

As illustrated by this review of literature, preparing teachers for technology integration is a complicated process involving far more than after-school workshops, or even advanced degrees. In this section, we highlight one promising technology integration training program in North Carolina known by the acronym IMPACT that takes a comprehensive, ongoing approach to reform through multiple measures.

In 2011, the North Carolina Department of Public Instruction (NC-DPI) posted a request for proposals (RFP) to distribute its share of federal *Enhancing Education Through Technology* (EETT) funds. The RFP described a two-phase program of initial training and follow-up support referred to as IMPACT. In phase one, selected schools form a team of four teachers, one principal, the school media coordinator, and the district technology director, to guide the initiative. Matching local funds provide teachers with laptops and required materials. Federal funds pay for participating principals to receive a 33-hour Educational Specialist (Ed.S.) degree in 21st Century School Leadership, and participating teachers to receive a 36-hour Master of Education (M.Ed.) degree in Instructional Technology with coursework from three different state institutions. Phase one also required participation in an online community and additional professional development. School teams were required to submit implementation and evaluation plans, and principals were required to provide monthly technology coaching for teachers. All participants were required to attend 85% of meetings and online community activities for the team to qualify for phase two. In phase two, teams successfully completing phase one were to receive up to $110,000 for classroom hardware and software, and continued professional development. At least 25% of phase two funds were to be spent on professional development, including summer academies. Beginning in fall 2011, thirteen schools received two-year grants from the program, including seven middle schools and six high schools, forming an initial cohort of 13 principals in the Ed.S. program and 52 teachers in the M.Ed. program.

Reflecting back to the literature outlined in this review, this IMPACT training program effectively combines several recommended programs into a comprehensive model of reform. For example, IMPACT reflects course and workshop approaches to integration training, by providing participating teachers and principals with a wide range of cross-curricular courses and ongoing, quarterly workshops on varied technology topics. IMPACT also reflects the coaching approach to integration training by providing principals with face-to-face and virtual coaching services from leadership and instructional consultants. In addition, by training a cohort of master teachers, they too become coaches or teacher-leaders in their schools. IMPACT reflects the learning community approach to integration training, as participating schools form small communities of practice who work together through courses, and the 13 schools overall combine to form a larger professional learning community who can interact in courses and through an online learning community. Finally, IMPACT reflects the product assessment approach to integration training, as graduate courses require a variety of products and teachers can pull together e-portfolios of work. Participating teachers have used outlets such as wikis, Web sites, Edmodo, and Moodle, to share lessons and resources with other teachers in their schools.

The IMPACT training program also purposely addresses several factors known to impact on integration practice, most notably including school leaders as key players in the training. Further, the program provides schools with funding for resources and requires districts to provide matching funds for teacher laptops. In addition, principals are required to provide human support in the form of technology coaches for teachers, and the program provides for ongoing professional development beyond degree-related coursework through quarterly workshops.

Over the course of this two-year grant, teachers and principals have gained important technology and leadership skills through the comprehensive IMPACT training program, and the knowledge gained from these activities has facilitated changes in the instructional technology landscape and school culture. In the first year of the grant, participating teachers conducted over 40 school-level technology sessions for non-participating peers at their schools, in addition to informal mentoring and collaborative lesson planning. Further, several schools have implemented school-wide interdisciplinary units featuring instructional technology strategies prominently. Comprehensive models of technology integration training such as IMPACT can be effective by combining different forms of training to teach multiple competencies, and by managing external and internal factors known to impact on integration practice.

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Table of Contents

SPECIAL TECHNOLOGY SECTION

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