Sprague, D. R., Zumpano, N. M., Richardson, J. W., Williamson, J., & Gray, L. (2023). Technology infusion and the development of practice: The quest to create digitally able teachers. *Contemporary Issues in Technology and Teacher Education, 23*(1), 199-227.

Technology Infusion and the Development of Practice: The Quest to Create Digitally Able Teachers

Debra R. Sprague
George Mason University

Nicole M. Zumpano
Learning Technology Center of Illinois

Jayson W. Richardson
University of Denver

Jo Williamson
Kennesaw State University

Lucy Gray
Lucy Gray Consulting

The third pillar of technology infusion is practice, providing numerous opportunities in multiple settings for teacher candidates to practice teaching with technology and to reflect on their experiences. Drawing from sociocultural theories of learning and change, this article offers a theoretical justification of this pillar and unpacks how infusing practice-based technology preparation will improve new teachers' ability to use technology in their classrooms. The authors discuss multiple types of practice, both in the teacher education courses and in K-12 field experiences. They argue that teacher preparation programs have been shifting to practice-based approaches for over a decade. However, not all preparation programs have adopted practice-based approaches that support the vision of a technology infusion approach. The article concludes with a discussion of design recommendations for practice elements of technology-infused programs needed for success.

This article is one of four articles in an invited special issue co-edited by Kevin J. Graziano, Teresa S. Foulger, and Arlene C. Borthwick that presents research-based design recommendations on the four pillars of a technology-infused teacher preparation program: (1) technology integration curriculum, (2) modeled experiences, (3) practice with reflection, and (4) technology self-efficacy. These pillars are essential components that work together to support successful program-deep and program-wide technology preparation.

Foulger (2020) proposed ongoing *opportunities for practice and reflection* as the third pillar for technology infusion. This pillar provides teacher candidates "many opportunities to practice integrating technology in a variety of settings" (p. 22). To help candidates advance their abilities to leverage technology effectively for teaching and learning, Foulger also stressed the importance of developmentally appropriate practice opportunities and repeated cycles of feedback and reflection within university courses and PK-12 field experiences. This article provides a deep dive into the theory, research, and recommendations to design a technology infused program that addresses practice as a central element of teacher candidate learning to teach with technology.

In 2018, the American Association of Colleges for Teacher Education's (AACTE) Clinical Practice Commission provided 10 proclamations that clarified clinical practice for university and PK-12 school partnerships. The purpose of the report was to highlight research-based recommendations as a foundation for effectively implementing evidence-based practice in teacher preparation programs. Figure 1 lists the 10 proclamations from the report (Clinical Practice Commission, 2018).

What becomes clear when reading these proclamations is that PK-12 schools and colleges and schools of education have a shared responsibility for preparing teacher candidates to be ready when they enter their first classroom. Candidates need to be prepared to meet the challenges encountered in classrooms, including the challenges associated with integrating technology in the teaching and learning process. To become effective in teaching with technology, teacher candidates need opportunities to practice learning and teaching with technology, to build their technology self-efficacy, and to develop an understanding of the affordances of technology (Sprague et al., 2022).

Theoretical Definition

The word *practice* may conjure images of students at a piano or athletes on the ball field. However, in the context of training teachers, practice is much more than repetitive actions to improve performance. For our conceptualization of practice-based approaches to new teacher technology preparation, we draw from sociocultural theories of learning and change, especially the concepts of situated learning, communities of practice, and legitimate peripheral participation (Lave & Wenger, 1991; Wenger, 1998; Wenger et al., 2002; Wenger-Trayner & Wenger-Trayner, 2020).

Figure 1
AACTE Clinical Practice Commission's Proclamations

Proclamation 1: Clinical practice is central to high-quality teacher education.

Proclamation 2: As pedagogy is the science of teaching, the intentional integration of pedagogical training into an educator preparation program is the cornerstone of effective clinical practice.

Proclamation 3: Clinical practice includes, supports, and complements the innovative and requisite skills, strategies, and tools that improve teacher preparation by using high-leverage practices as part of a commitment to continuous renewal for all learning sites.

Proclamation 4: Clinical partnerships are the foundation of highly effective clinical practice.

Proclamation 5: Sustainable and shared infrastructure is required for successful clinical partnership.

Proclamation 6: Clinical partnerships are facilitated and supported through an understanding of the continuum of development and growth that typifies successful, mutually beneficial collaborations.

Proclamation 7: As emerging professionals, teacher candidates are essential contributors and collaborators within clinical programs and partnerships.

Proclamation 8: Boundary-spanners, school-based teacher educators, and university-based teacher educators play necessary, vital, and synergistic roles in clinical educator preparation.

Proclamation 9: Coalescing the language of teacher preparation and teaching around a common lexicon facilitates a shared understanding of and reference to the roles, responsibilities, and experiences essential to high-quality clinical preparation.

Proclamation 10: Teaching is a profession requiring specialized knowledge and preparation. Educators are the pedagogical and content experts. It is through the assertion and application of this expertise that they can inform the process and vision for renewing educator preparation.

According to Wenger (1998), practice is more of a noun than a verb. In his words, practice is a broad concept representing the socially constructed set of beliefs, norms, and actions that professionals develop over time:

> Practice includes both the explicit and the tacit. It includes what is said and what is left unsaid; what is represented and what is assumed. It includes the language, tools, documents, images, symbols, well-defined roles, specified criteria, codified procedures, regulations, and contracts that various practices make explicit for a variety of purposes. But it also includes all the implicit relations, tacit conventions, subtle cues, untold rules of thumb, recognizable intuitions, specific perceptions, well-tuned sensitivities, embodied understandings, underlying assumptions, and shared worldviews. (p. 47)

In this sense, practice is inextricably linked or *situated* in the social setting in which it occurs. Over time, competent practice improves through the enduring activity and meaning-making processes of a community of practice (CoP), a group of people united by shared goals, problems, and tasks (Lave & Wenger, 1991; Wenger, 1998; Wenger et al., 2002). Wenger-

Trayner and Wenger-Trayner (2020) further defined CoPs as having a "commitment to playing, developing, and improving a shared practice" and recognizing members by their "regime of competence" (p. 32). Becoming a full-fledged member of a CoP is not only supported by social interaction and activity of its members but is also mediated through it. Newcomers advance their knowledge, skills, and even personal and professional identities through increasingly complex engagement, or legitimate peripheral participation (LPP), in community life.

During LPP, newcomers engage in developmentally appropriate activities that enhance their professional performance. While novices may begin honing their practice in the periphery of communal activity, they eventually progress to full-fledged members who artfully contribute to communal work. During this engagement in mutual activity, novices also encounter tools critical to completing professional tasks and become adept at using them (Wertsch, 1998). The expected length of time required to progress from novice to veteran practitioner is influenced by the inherent complexity of community tasks; access to authentic learning opportunities; and the quality of social support provided (Lave & Wenger, 1991; Wenger, 1998).

Vygotsky's (1978) concept of zone of proximal development (ZPD) is another useful construct to describe the socially supported, practice-based experiences novices need to fully develop expert performance. ZPD defines situations where learners cannot entirely address new tasks independently, but they can be successful with support from expert mentors or more capable peers. In this sense, ZPD represents the optimal context for practice-based learning where tasks are challenging but achievable with scaffolding and prompts. As novices become more adept, their ZPD shifts and their learning experiences become increasingly complex.

Perhaps fueled by calls to strengthen clinical practice (Clinical Practice Commission, 2018), current methods for training new teachers seem well-aligned to sociocultural tenants of learning such as LPP, COPs, and ZPD. For example, novice teachers typically begin their programs with more peripheral, less demanding tasks, such as observing PK-12 instruction, microteaching to peers, and designing lesson plans in their methods courses. Near the end of their programs, they are likely to participate in extended clinical experiences and assume greater instructional responsibilities in actual PK-12 classrooms. Along the way, teacher education faculty members, PK-12 mentor teachers, and university clinical supervisors play a pivotal role in the development of competent teacher candidates.

Through direct instruction, modeling, and coaching, these more knowledgeable community members scaffold novice performance to higher levels of proficiency and help them reflect on their emerging instructional practices. Yet, current research suggests that technology may not be consistently and systematically infused into these practice-based approaches (Clausen et al., 2021). For this reason, we continue to discuss concepts related to practice-based learning in the following sections and share our vision of how technology preparation with teacher candidates might be improved.

Defining Practice

The adage that "practice makes perfect" applies to teacher candidates learning to integrate technology into PK-12 classrooms. If university preparation programs want teacher candidates to be well-prepared to use technology in their first-year of teaching, then candidates must be provided with multiple opportunities to use technology during their teacher preparation program. Opportunities for practice involve helping teacher candidates address common challenges related to technology infusion, developing the knowledge, skills, and dispositions associated with technology integration (Grossman et al., 2009; Shulman, 1998). Such opportunities allow teacher candidates to grow and develop self-efficacy with integrating technology in teaching and learning (Williams et al., 2023).

Grossman et al. (2009) developed a framework for practice with three components: (a) representations of practice, (b) decompositions of practice, and (c) approximation of practice. Representation of practice involves teacher candidates watching more experienced teachers teach. This can be done through modeling by the teacher education faculty, observing PK-12 teachers in the field, or watching videos that demonstrate specific teaching techniques.

Grossman et al. (2009) criticized these representations for not providing a complete picture of teaching. Teacher educators modeling university-level activities for their students are actually teaching adults, so the teacher candidates do not see how children might respond to a similar activity. Watching a video of teaching may allow a candidate to see a specific strategy in action, but does not always provide information on the teacher's thought process during the activity. Exceptions may be found.

The Teaching Channel provides short videos that can be used to show how various strategies are used in the classroom. These short videos are parts of longer videos in which teachers explain their teaching process, the research behind the strategy, and the outcome of the lesson. Representation of practice might result in candidates focusing on some aspect of the lesson not intended by the faculty member. "Professional educators need to be mindful of the range of meanings that representations convey and provide opportunities to debrief these representations with students" (Grossman et al., 2009, p. 2068).

As a defining characteristic of technology infusion, teacher educators model the use of technology. However, Clausen et al. (2021) reported teacher educators had "various levels of confidence in their ability to model technology use with candidates" (p. 23). Therefore, it is important that colleges and schools of education invest in helping teacher educators to develop their knowledge and skills related to technology usage (Jin et al., 2023). In addition, modeling should be supplemented with the opportunity for teacher candidates to see technology integrated lessons taught with PK-12 students. Candidates should have the opportunity to reflect and discuss with the teacher how they approached the lesson and how they would improve it (Grossman et al., 2009).

Decompositions of practice, the second component of Grossman et al.'s (2009) framework for practice, refers to breaking down the complexity of teaching into its various components so these discrete parts can be taught individually. For candidates to be able to integrate technology into a lesson, they need to know how to design lessons that use technology, how to choose appropriate technology, and how to operate the technology they selected. They need to know classroom management strategies and how to troubleshoot problems in the classroom. Some of these skills, such as designing lessons and selecting appropriate technology, can be taught in methods courses. Other aspects, such as classroom management, can be taught in the PK-12 classroom. As the teacher candidates practice and reflect on these various aspects of using educational technology, they become routine (Ericsson, 2002).

Approximation of practice, the third component of Grossman et al.'s (2009) practice framework, refers to opportunities for teacher candidates to practice teaching. Grossman et al. discussed the use of microteaching in university classrooms as an example of approximation of practice. Microteaching involves activities in which teacher candidates teach lessons to their peers who take on the role of K-12 students (Allan, 1967). Simulations, including opportunities to use virtual reality, are also included in approximation of practice (Grossman et al., 2009). Simulations provide teacher candidates the opportunity to interact in a virtual classroom with avatars representing the K-12 students (Bradley & Kendall, 2014).

Although these activities are not entirely authentic in terms of their audience or execution, they can provide opportunities for students to experiment with new skills, roles, and ways of thinking with more support and feedback than actual practice in the field allows. (Grossman et al., 2009, p. 2077).

Christensen et al. (2011) explored teacher candidates' use of an online simulation designed to help the candidates develop skills in differentiation. They found the use of the simulation provided immediate feedback and allowed the teacher candidates to try out a variety of strategies without fear of failing. In the following sections, we discuss ways microteaching, simulations, and virtual reality can be used to support practice in a technology infused program.

Microteaching

Microteaching lessons are often taught within the teacher education courses under the watchful eye of the instructor and usually focus on the content of the method course or a specific strategy. Microteaching allows teacher candidates to put theory into practice, try out new skills, and recognize their strengths and areas for improvement (Fisher & Burrell, 2011).

Using videos of the teacher candidates' microteaching experience, peer feedback, mind maps created by the candidates, and focused interviews, Arslan (2021) found that microteaching "significantly helped participants gain teaching knowledge and develop teaching skills" (p. 276). In Arslan's

study, teacher candidates recorded two separate videos of their microteaching. Candidates received feedback from their peers after their first microteaching lesson. They, in return, provided feedback to their peers on their microteaching lesson. The candidates were then provided the opportunity to teach a second lesson. Arslan stated that having the opportunity to view and critique their first video, reflect on peer feedback, and watch their peers' microteaching lessons helped the candidates improve their own teaching on their second attempt.

Simulations

Simulations allow teacher candidates to practice teaching to virtual avatars in a virtual space. These avatars can be controlled either by a real person in a virtual space or by a computer. Although the ideal situation is to have teacher candidates work with real children in a real classroom, simulations can provide candidates with the opportunity to hone their teaching skills by focusing on a certain component of the teaching and learning process, such as classroom management or differentiation of instruction.

Bradley and Kendall (2014) identified three types of simulations currently available to teacher educators: (a) virtual puppetry; (b) multi-user virtual environments (MUVEs); and (c) single user simulations. Virtual puppetry refers to a synchronous environment in which the candidate interacts with actors playing the role of students. The actors are interacting in real-time through a computer and are responding to decisions made by the teacher candidate. MUVEs are a virtual environment in which multiple teacher candidates can interact synchronously. Single user simulations are preprogrammed responses to interactions between the candidate and virtual students represented by avatars. The candidates decide how to proceed, and that triggers a response from the avatar. Unlike the virtual puppetry, which is controlled by a human being, the avatars in this scenario are controlled by the computer.

Research has shown that engaging teacher candidates in simulations can have a positive impact on their practice and self-efficacy. Davis et al. (2022) had teacher candidates develop problem-based lessons that were then taught in a MUVE. The researchers found that practice and instructional time strongly influenced engagement within the simulation, which then influenced instructional effectiveness.

When preservice teachers felt present in the space and had time to immerse themselves in successful practice teaching, that resulted in positive outcomes (e.g., meaningful engagement in the virtual classroom lessons, teaching efficacy, and the belief that their effective teaching could translate to their students' success in mathematics). (Davis et al., 2022, p. 16).

Pendergast et al. (2022) found that teacher candidates reported higher self-efficacy toward technology and development of technological and pedagogical confidence when they used a MUVE as part of their practice.

Virtual Reality

The term virtual reality (VR) has been used to address a wide range of interactions with a computer. However, for the purpose of this article we define VR as being a fully -immersive, three-dimensional environment using a head-mounted display. The teacher candidate is able to walk around the virtual classroom, in all directions, and interact with virtual students, much like in a real classroom. In the VR environment, the virtual students are controlled either by a real person or a computer who responds to the choices made by the teacher candidate.

Lamb and Etopio (2019) compared teacher candidates in a traditional clinical experience with candidates whose clinical experience was conducted solely in a VR environment. The researchers filmed footage from the classroom used for the clinical experience portion of the study. This footage was used to create the VR classroom. Interactivity in the VR classroom was created using Unity code. The results showed no significant difference between the two groups and the researchers concluded that candidates were "able to apply skills learned in VR to real classroom situations" (Lamb & Etopio, 2019, p. 165).

Due to the COVID-19 pandemic and the need to social distance, educators have become interested in the use of simulations and VR technology in teacher preparation. When schools closed and students were moved to virtual learning, many teacher education programs struggled to provide teacher candidates opportunities to practice teaching. Some turned to virtual simulations as an alternative (Hayes et al., 2021). As the pandemic moves to an endemic level, teacher educators should consider the lessons learned from preparation programs that used VR to supplement traditional field experiences (Ferdig et al. 2022).

Ferdig et al. (2022) provide three reasons for including VR field experiences as part of a teacher education program. First, there is a chance that another pandemic or disaster will once again close schools. Second, PK-12 online school has been around for a while and the number of PK-12 online schools is growing. Teacher education programs have a responsibility to prepare their teacher candidates to teach in all modalities they could face as professionals, including hybrid and virtual learning environments. Third, some school districts limit how many teacher candidates they will accept. This means that candidates may not get into a PK-12 school until their third or fourth year in the program. By using VR, teacher candidates are able to practice teaching strategies with virtual students prior to entering the real-life classroom.

Lamb and Etopio (2019) provided a fourth reason: Field experiences vary widely based on the cooperating teacher, school demographics, and other factors. The level of support received by the cooperating teacher means that some candidates have effective experiences, while others may struggle. Using VR and simulations allows for some uniformity and consistency for the candidates. It also allows candidates to experience the learning potential of these technologies.

Clinical Experiences

Grossman et al.'s (2009) framework helps teacher educators to think about three components of practice. However, the framework does not discuss clinical experiences in the PK-12 classroom. Although the use of microteaching, simulations, and VR can provide opportunities for teacher candidates to practice specific skills, these techniques are removed from real children in real classrooms. At some point, to claim proficiency with technology integration, teacher candidates must enter a PK-12 classroom, plan, and teach lessons that are supported by technology, and reflect on the experience.

When considering a technology infusion model, one must not only consider opportunities to practice within coursework but also reflect on the clinical experiences available to the teacher candidate. Research has shown technology experiences do not automatically transfer from university coursework to clinical experience (Sprague & Katradis, 2015).

Tiba and Condy (2021) found in their study that modeling from both teacher educators and PK-12 in-service teachers were factors that supported teacher candidates' use of technology. When presented with different models of integrating technology, teacher candidates resorted to the in-service teachers' ways of using technology (Polly et al., 2020). For example, in Polly et al.'s study, teacher education faculty members focused on technology use that promoted higher order thinking, such as the development of virtual field trips and problem-based learning. The in-service teachers focused on lower order thinking activities that involved interactive white boards, videos, and games as ways to integrate technology.

The researchers also looked at how teacher candidates used technology in their lessons. They discovered that the teacher candidates adopted the formats modeled by the in-service teachers. Therefore, it is imperative that teacher educators and in-service teachers in PK-12 classrooms work together to provide practice opportunities that are articulated across coursework and field-based experiences, find more effective ways to leverage university-based practice experiences and field-based practice experiences, and develop teacher candidates' technology, pedagogy, and content knowledge, or TPACK (Mishra & Koehler, 2006).

Clinical experiences serve multiple functions in the development of teacher candidates. They provide an opportunity to explore methods of teaching through situation-specific occurrences that arise throughout the day, enable candidates to develop an understanding of students and student needs, and allow candidates to develop a connection between theory and practice (Sun et al., 2016; Williamson & Moore, 2017). Providing teacher candidates opportunities to practice integrating technology during their clinical experiences enables them to develop the knowledge and skills needed to use technology in their future classrooms (Sun et al., 2016).

Sun et al. (2016) explored the impact student teaching had on teacher candidates' readiness to integrate technology. They found teacher

candidates who had the opportunity to teach lessons prior to student teaching were more prepared to integrate technology in PK-12 settings than those who did not have the opportunity to teach lessons prior to student teaching. These early teaching experiences provided the teacher candidates with the opportunity to become familiar with technology being used in the classroom and to have real world practice with planning and teaching with technology, thereby increasing their confidence with using technology in the classroom.

Foulger et al. (2020) called for a new paradigm in field experiences, one providing opportunities for teacher candidates to practice integrating technology. They provided a list of different practice types that teacher education programs can use to be more intentional about how they prepare teacher candidates to be confident and proficient with integrating technology. These practice types included (a) mechanical practice; (b) goal-oriented practice; (c) competency-oriented practice with feedback; (d) vision-oriented practice; and (e) asset-based practice.

Presenting teacher candidates with multiple opportunities to engage in these various types of practice within the PK-12 classroom, providing useful feedback, and offering them ongoing learning about the integration of technology throughout their program will help prepare teacher candidates to fully leverage the use of technology (Foulger et al., 2020). Providing these opportunities and identifying technology using teacher mentors requires teacher preparation programs to work closely with school leaders. The next section explores the role of school leaders in supporting practice, the third pillar of technology infusion.

The Role of School Leaders

In their seminal report to the Wallace Foundation, a philanthropic organization that is committed to improving school leadership, Leithwood et al. (2004) argued that school leadership is second only to classroom instruction when it comes to impacting student learning, and leadership is the catalyst to improve schools. School leaders clearly impact learning, teaching, and school improvement. School leaders, who guide teachers and teaching candidates with feedback, support, and guidance, are key to technology integration (Richardson et al, 2015; Sterrett & Richardson, 2019).

A core element on reflecting and practicing technology integration involves conversations with teachers and leaders. To empirically investigate these intersectional conversations, Dexter and Richardson (2020) conducted a systematic review of the literature to understand better the intersection of technology, teaching, and leadership. The authors sought to understand the ways in which the technology integration literature identified leadership practices that support classroom technology integration. Findings from the review of literature produced only 34 articles. The findings suggest that researchers rarely offer teacher technology integration implications for school leaders, despite findings that show principals who set the direction for technology integration in classrooms understand systems change, are good at building trust with teachers and staff around technology integration, advocate for their

teachers about technology integration, and build a culture that supports technology integration (Richardson et al., 2021).

To help teachers and school leaders practice and reflect on technology integration, McLeod (2018) created the 4 Shifts Protocol. This protocol is used to help leaders (principals, instructional coaches, and/or teacher mentors) support teachers' and teacher candidates' lesson redesign where technology is purposely infused into teaching and learning. By focusing on deeper thinking and learning, authentic work, student agency and personalization, and technology infusion, the protocol gives leaders language and "look-fors" to help teachers and candidates reflect on how and why technology is being used.

One aspect of the literature that is scant however, is how school leaders work with teacher candidates or teacher preparation programs to ensure that the next generation of teachers is ready and has the self-efficacy to *integrate technology* in their own classrooms (see U.S. Department of Education [DoE], Office of Educational Technology [OET], 2017). As noted by Proclamation 8 of the Clinical Practice Commission's (2018) report (see Figure 1), there is a need for boundary-spanners to bridge the gap between what happens in the university classroom and what is applied in clinical experiences.

School leaders can serve as boundary spanners by supporting a smooth transition from preparation to induction, by providing technology-rich experiences for teacher candidates and by hosting student clinical experiences that emphasize the importance of technology integration. Thus, the pipeline from teacher candidate to an in-service teacher who is skilled at technology integration requires involvement of school leaders. This skill includes teaching in various modalities including face-to-face, online, and hybrid (Ferdig et al., 2022). The research also noted a need to train teacher candidates to teach in virtual schools through online student teaching experiences (Graziano & Feher, 2016).

In circumstances where the willingness of in-service teachers to become a mentor teacher is low, expertise in teaching with technology and in mentoring teacher candidates in developing their technology skills may not be a criterion for selection. The literature does not specifically address how college and school of education leaders can work with district superintendents or principals to establish formal approaches that ensure teacher candidates get robust clinical experiences with technology integration.

Constructivist learning theories, such as situated learning, suggest the best context to facilitate learning about teaching with technology is in PK-12 classrooms, where the teacher candidate is partnered with a mentor teacher whose role is to support the teacher candidate in becoming a legitimate agent of teaching and learning (Lave & Wenger, 1991). In a technology infused teacher preparation program, mentor teachers should have a student-centered approach to teaching with technology (Foulger et al., 2019). As such, mentor teachers should support teacher candidates to explore novel uses of existing technology and new technological devices in ways that feel safe for both the mentor teacher and teacher candidate. This means mentor teachers must support teacher candidates to learn and

apply technology, pedagogy, and content (Mishra & Koehler, 2006), and account for the *contextual affordances and barriers* in their teaching (Mishra & Koehler, 2006; Mishra, 2019).

Practitioners and researchers are apparently concerned with how teacher preparation programs and mentor teachers can help teacher candidates hold true to *their intentions to teach with technology,* regardless of the contextual factors they are faced with in their future. These contextual factors are not only the technology teacher candidates may encounter, but also societal events that may cause a shift in how one teaches, such as the COVID–19 pandemic that resulted in a shift to online learning throughout the world.

Impact of COVID-19 Pandemic

In early 2020, schools across the world closed abruptly due to the COVID-19 pandemic. Educators had to amend curricula and transition quickly to provide online instruction. Students and teachers had to strengthen their technology skills, and teachers had to adopt new teaching styles that were supported by online tools. Technology was a necessary medium (Gomez et al., 2021) for continued learning under difficult circumstances. Teachers lacking in-depth pedagogical knowledge of technology found this transition to be even more stressful. Good in-person teaching does not equate with good online teaching (Eaton, 2020). Educators new to the profession, who had limited exposure to technology in their teacher preparation programs and had inconsistent experiences with technology in their own PK-12 schooling, provided inequitable student experiences during online learning, as they did not have a foundational understanding or prior experience to draw from (Ebersole, 2019).

Today, schools have returned to in-person learning. Emergency remote learning related to COVID-19 is no longer necessary, and PK-12 faculty and staff have begun to reflect on the pandemic experience. Many stakeholders recognize the benefits that technology brought during the pandemic and have begun to prioritize the necessity of being better prepared for supporting online mode of learning. School districts that were not 1:1 with technology before the pandemic, where each student did not have access to a digital device, now find themselves with increased access and availability (Van Ness & Varn, 2021). Teacher candidates in teacher preparation programs must be prepared to use technology in their future classroom. Teacher candidates who understand the how, why, and when to integrate technology, influence successful integration (Gomez et al., 2021).

Global pandemics and weather-related school closures are not the only reason educators should learn to integrate technology effectively. As emphasized by the World Economic Forum, students will need specific skills related to technology, such as design and programming, to navigate future careers successfully (Whiting, 2020). The workforce landscape is increasingly changing with the advancement of technology (Bughin et al., 2018). By ensuring teacher candidates are prepared to use technology before transitioning to the classroom, PK-12 students will be exposed to the skills needed to be successful in future careers.

Although many new teachers are familiar with current technologies used in social circumstances, they do not necessarily have the pedagogical knowledge necessary to integrate technology effectively. There may be differences between what teacher candidates observe in field experiences and what they have learned in their academic program (Ebersole, 2019; Polly et al., 2020). Further emphasized by Ebersole, candidates may or may not have the opportunity to employ practices they have studied in their teacher preparation programs.

These future educators are eager to learn about the role technology can play in their profession. Survey results from the *Closing the Gap to Create the Ideal Learner Experience* survey (UNESCO, 2022) showed that learners globally want and expect technology to be more prevalent in their higher education experience. In a study that looked at the preservice technology experience of novice teachers and examined their perceptions of how well their teacher preparation program ensured they had the knowledge and skills necessary to fulfil the *National Educational Technology Standards*, now known as the ISTE Standards (International Society for Technology in Education, 2022b), Sutton (2011) wrote that teacher candidates must be provided with authentic learning experiences using technology throughout their teacher preparation program. PK-12 students deserve to learn from teachers who are prepared to integrate technology successfully (U.S. DoE, OET, 2017). The following section describes program recommendations for improving technology integration for teachers in training.

Program Design Recommendations

Some steps can be taken in teacher preparation programs to help prepare future educators to walk into classrooms with the knowledge needed to integrate technology effectively. While research reflects that meaningful technology integration remains a challenge facing today's teachers (Gomez et al., 2021), there are steps teacher preparation programs can take to lessen this.

The following are our recommendations for programs as they consider how the development of a teacher candidate's practice can be supported in an infused approach to learning to teach with technology. See the appendix for a list of resources that can help teacher preparation programs implement technology infusion.

Ensure Teacher Educators Can Meet the TETCs

Researchers have developed the Teacher Educator Technology Competencies (TETCs) (Foulger et al., 2017; Slykhuis et al., 2020). These competencies are a comprehensive set of skills, knowledge, and behaviors teacher educators should have in relation to teaching teacher candidates how to integrate technology. In order to infuse technology successfully in the teacher preparation program and to prepare teacher candidates effectively to use technology, teacher education programs should ensure all teacher education faculty members are able to meet the TETCs. This will require supporting teacher educators to review current courses to address teaching with technology in ways that match with but do not

overshadow the core curricula (i.e., is infused) and providing opportunities and incentives for them to engage in ongoing professional development.

The TETCs also suggest teacher educators explicitly address how "practice" teaching with technology is woven into their coursework. For example, teacher educators who teach methods courses should be prepared to incorporate TETC 2 (incorporate pedagogical approaches), TETC 3 (integrating technology within a given content area), TETC 5 (differentiation), and TETC 6 (assessment) into their given course content.

Provide Access to Basic Skills for Technology Used in PK-12 Classrooms

While there is no way to predict what the future landscape will look like for educators in terms of technology that is available in their classrooms, there are devices that are currently used by PK-12 districts. Having access and familiarity with tools such as Chromebooks, iPads, and learning management systems, for example, will enable novice teachers to be able to focus on how technology connects to learning goals instead of having to learn how to use the equipment. According to results from a *Speak Up* survey with over 110,000 educational stakeholder respondents (Project Tomorrow, 2021), 65%-82% of students in grades 3-12 during the pandemic were assigned a Chromebook. While Chromebooks are not the sole devices used in PK-12 education, they are the most prevalent and should be available in teacher preparation programs.

Not only should teacher candidates be able to use educational technology and mobile devices, but they should also be taught the affordances provided by a 1:1 classroom. Anderson et al. (2015) identified three best practices for the use of 1:1 technology: (a) providing examples of meaningful differentiated instruction, (b) addressing identified needs of exceptional learners, and (c) providing opportunities to use constructivist pedagogy to improve student understanding and retention of new concepts.

Introduce Teacher Candidates to the Accessibility Features of PK-12 Technologies

According to the National Center for Educational Statistics (2022), 7.2 million children ages 3-21 received special education services in 2020-2021. This does not include those who have temporary disabilities due to illness or injury or students who are not formally diagnosed with a learning disability. Technology devices in PK-12 classrooms have built-in features that can make content more accessible for these students, as well as all others. For example, iPads and Chromebooks have screen readers for students who may be visually impaired. Closed captioning, text sizing, translation, and color contrast are additional features to help not only students with disabilities but also English language learners. Teacher preparation programs need to introduce and provide experiences with universal design for learning (CAST, 2018). The universal design for learning framework focuses on multiple means of engagement,

representation, access, and expression for all students, not just those with disabilities.

Adopt Research-Based Frameworks for Measuring the Effectiveness of Teaching With Technology

Technology integration should be done with purpose and relevance to learning objectives. Technology frameworks can be used as instructional guides to help teacher candidates reflect on the purpose of technology's use during instruction (Kolb, 2016, 2020a,b). To inform and evaluate instructional technology tools, educational technology frameworks should be introduced to teacher candidates at varying stages throughout their teacher preparation program. A foundation for the role of technology in education should be established using the Technological, Pedagogical, and Content Knowledge (TPACK) theoretical framework developed by Mishra and Koehler (2006). This framework allows teacher candidates to think about how content, pedagogy, and technology blend together to instruct in a way that allows students to meet learning objectives. The TPACK framework helps teacher candidates understand that technology is not an add-on but interacts with the content and pedagogy of a lesson, which helps inform the selection of technology.

Another logical framework to study is SAMR, which is an acronym for stages of technology integration: substitution, augmentation, modification, and redefinition. Developed by Ruben Puentedura (2013), SAMR helps teachers evaluate the types of technology used and for what purpose. Each stage of SAMR increases the functionality and outcomes the technology can provide. Often referred to as a ladder, teachers begin to reflect on the purpose for technology when using this model. For those who are not comfortable with technology integration, the SAMR model allows them to integrate technology in phases.

The Triple E framework, developed by Liz Kolb in 2016, is centered on assessing if the technology used in classrooms engages, enhances, and extends the learning objective. Engagement is not focused solely on capturing the attention of students but ensuring they are actively involved with the content that is being presented. Enhancement of learning goals with technology is evident when a tool assists or scaffolds learning in a way that could not be done easily without the technology. Extension of learning takes place when technology allows for learning goals to connect with students' real-world experiences and can include the enhancement of soft skills students will need in the work force. This framework might be best introduced later in a program during a time when teacher candidates experience planning for and teaching with technology in clinical experiences.

When exploring online teaching and learning, teacher candidates should study the Community of Inquiry framework. This framework focuses on the interaction of teachers and students through three elements: (a) the social presence, (b) the cognitive presence, and (c) the teaching presence (Garrison et al., 1999). Social presence is focused on how the learner identifies with the community they are a member of. Teaching presence consists of instructional design, organization of the materials, and

facilitation of discussions. Cognitive presence involves motivating students to engage cognitively with content (see also McVay, 2020).

Another framework for online education is the Adolescent Community of Engagement framework (Borup et al., 2014), which focuses on online learning in K-12. This framework consists of four main parts: (a) student engagement, (b) teacher engagement, (c) peer engagement, and (d) parent engagement. The focus of this framework is on student engagement. Borup et al. hypothesized that as teacher, peer, and parent engagement increases, student engagement will also increase, which will lead to learning in the online environment.

While these various frameworks will not help a teacher determine if the technology is impacting learning, they may help teachers to understand when technology is simply being used for technology's sake as opposed to increasing student comprehension. These frameworks can help teacher candidates design effective lessons in which technology is used to enhance students' understanding of the content.

Introduce ISTE Standards

ISTE (2022b) developed a series of standards for educational technology stakeholders, including teachers, leaders, and students. Teacher education programs are expected to provide evidence that their teacher candidates are able to plan lessons and teach with technology. Some states have adopted the ISTE Certification Program as part of their licensure endorsements. In Maryland, ISTE-Certified educators can qualify for continuing professional development credits. In Wyoming and Utah, the ISTE Certification qualifies educators for the instructional technology endorsement (ISTE, 2022a). Using the ISTE Educator Standards as the foundation, teacher education programs can design experiences that enhance teacher candidates' knowledge, skills, and self-efficacy toward teaching with technology.

The ISTE Student Standards have been adopted, adapted, or endorsed by all 50 states (ISTE, 2022a). Adoption of the ISTE Student Standards means that the board of education, state legislation, or state education agency has formally approved the standards to be used in the states. States that have adapted the ISTE standards borrow elements of the standards to incorporate into their own set of educational technology competencies. States that endorse the ISTE standards encourage districts to use the standards, but provide no mandate to do so (ISTE, 2022a).

Since all 50 states have adopted, adapted, or endorsed the ISTE Student Standards, they should be introduced in teacher preparation programs across the curriculum. Teacher candidates should be exposed to the ISTE Student Standards in the beginning, foundation courses. During methods and field experience courses, candidates should be required to plan and teach lessons that include the ISTE standards, receive feedback on these lessons, and reflect on ways to improve their practice.

Ensure Teacher Candidates Are Comfortable With Online Teaching

While brick-and-mortar classrooms will not likely disappear, online learning will continue to increase. Beyond the obvious, that some PK-12 students benefit from engaging in learning experiences anytime, anywhere, and with the affordances of technology to support disabilities, PK-12 school systems are now able to adjust to global pandemics and other nature-related events such as wildfires, hurricanes, and water crises that may push them to online modalities. Since the COVID-19 pandemic, school systems are nimbler about the instant shift to online learning. As evidence of this, research by Nicosia (2021) found that 39% of principals and school district leaders shifted snow days to remote learning days after the pandemic, and an additional 32% of the principals indicated they are considering the same. For these reasons, teacher preparation programs need to ensure future educators are comfortable with online teaching.

Teacher candidates should experience an online course as a learner as well, which is supported by teacher candidates themselves. In a survey of 2,725 students, 80% preferred that at least some of their courses or meetings take place online (UNESCO, 2022). Some states have begun setting requirements in place to see that this occurs. The Digital Learning Collaborative (2018) noted that some states make this a graduation requirement.

Beyond experiencing an online course as a learner, teacher candidates should be taught how to effectively design online experiences that are specific for the learning, supervision, and assessment needs of PK-12 students. Instructional design principles that target online instruction for PK-12 students are critical components (McVey, 2020). Examples of skills teacher candidates should focus on include screencasting, designing for accessibility, website creation tools, and self-paced lessons.

Although some teacher preparation programs may formally offer teacher candidates instruction on online teaching, the majority do not. Reasons for this include too many state licensure requirements that leave no room for other courses, lack of faculty members with online teaching experience, and a lack of demand for online courses (Graziano & Bryans-Bongey, 2018). Sprague and Wilbern (2021) called for universities to provide ongoing support to help faculty members develop online teaching skills by providing instructional designers to work with faculty members, providing time to develop online courses, and offering professional development opportunities. They also called for universities to require all students take an online course as part of their educational experience. Their research with university students showed that those who had experience in online classes were more positive about transitioning to online learning during the pandemic.

In a national survey on preparing teacher candidates to teach online, Graziano and Bryans-Bongey (2018) found the most common considerations for preparing teacher candidates to teach online included offering individual or optional courses, certificate programs, or graduate level programs. In terms of preparing faculty members to teach such

courses, Graziano and Bryans-Bongey also recommended using instructional design resources, online courses, and webinars.

For those teacher preparation programs lacking the resources to provide faculty support, resources such as Quality Matters (2022) may help. Quality Matters provides quality assurance tools for online teaching resources, including research, rubrics, and course design reviews (McVey, 2020). No matter how teacher preparation programs approach the issue of preparing teacher candidates to teach online, it is imperative that they do so. When teacher candidates have experienced online learning both as a learner and a designer, they will be prepared to transition to online instruction.

Build Professional Learning Networks

Starting a new career in education can be challenging. There are many facets to teaching, such as establishing relationships, writing lesson plans, and developing units of instruction, to name a few. While enrolled in their teacher preparation programs, teacher candidates should begin to develop their professional learning networks. Joining professional organizations, such as ISTE and the Association for Supervision and Curriculum Development, can help them to connect with practicing teachers and attend webinars and conferences that expand on ideas presented in their teacher education courses. Such organizations can extend the teacher candidates' knowledge while expanding their professional network.

Once teacher candidates transition to in-service teachers, there are additional opportunities for teacher preparation programs to support them. Teacher preparation programs can provide ongoing support through webinars, podcasts, and online modules (Williamson & Moore, 2020) helping novice teachers transition into an existing community of practice that includes fellow students, program faculty members, and mentor teachers (Ebersole, 2019).

Teacher candidates could benefit from teacher educators' and mentor teachers' support during and after their transition to the classroom. In fact, 40% of students strongly agree they would like to receive more support from their university after they graduate, and 58% want more career-focused services designed to help them secure a job after graduation (UNESCO, 2022). Universities have explored ways to stay connected with and support teacher candidates as they transition to in-service teachers, such as informal conferences like Edcamps (Digital Promise, 2022), online webinars, and focus groups with alumni in the field. Program designers should consider additional and more connected ways that allow new teachers to stay connected with their university. Having a postgraduation orientation to support new teachers could also help universities keep their pulse on what is currently happening in PK-12 classrooms.

Build Partnerships With PK-12 School Leaders

Higher education faculty members should build functioning partnerships with PK-12 leaders so that stakeholder interests are represented in the

decision-making process involving the design of technology infused programs. There is evidence that, in some cases, strong partnerships have benefitted teacher candidates' practice. For example, George Mason University's Elementary Education Program supports theory-to-practice connections by partnering with three local school districts committed to working with teacher candidates and the university in a multiyear program (Sprague et al., 2020). Additionally, in Georgia, Kennesaw State University has an advisory board to align technology initiatives in PK-12 schools with teacher preparation curriculum (Williamson & Moore, 2017). In Tennessee, the state board of education is a model for a *Grow Your Own* teacher pipeline program, which currently includes 65 programs among 14 universities (Merod, 2022). This approach often provides college credit and financial support to high school junior and senior students interested in receiving credit toward a teaching degree.

The building of relationships with PK-12 stakeholders is supported by the American Association of Colleges for Teacher Education (AACTE). As noted earlier, AACTE's Clinical Practice Commission and their 10 Proclamations calls for a stronger partnership between colleges and schools of education and PK-12 schools. Through the building of partnerships between universities and PK-12 schools, teacher candidates receive a consistent message of the expectation to integrate technology effectively.

Strengthen Teacher Mentorship Programs, Induction Programs, and Field Experiences

Technologically savvy and proficient teacher mentors are key to teacher candidates building their self-efficacy in integrating technology into their teaching (Nelson, 2017). Mentor teachers with high TPACK scores inspire teacher candidates to use technology more frequently. Conversely, teacher candidates are less likely to try using technology in classrooms if they worked with mentors who are not technology savvy. Thus, teacher preparation programs should develop teacher mentorship programs to ensure that teacher mentors receive sufficient professional development. It is also essential that there is a process for matching mentors and teacher candidates, and activities should be designed to help these teams understand power dynamics and build the relationships necessary for successful collaboration. All efforts should be made to pair teacher candidates with teacher mentors that understand how to integrate technology in the classroom.

One model is to develop a coteaching clinical residency program, where mentor teachers and teacher candidates collaborate on lesson planning, instruction, and assessment and have the opportunity to reflect together (Helmsing et al., 2022). This model supports professional growth for both the teacher candidate and the mentor teacher. Mentor teachers in coteaching models reflect on their own teaching practices, are inspired by working with new teachers, and are open to trying new approaches, including ones involving technology. In this model, both participants offer support and feedback to one another, which benefits their pedagogical practices.

Another collaborative model in program design utilizes four cycles with its mentor teachers and teacher candidates (Liu et al., 2014). Mentors demonstrate technology teaching activities in the first and third cycles, while teacher candidates keep observation records. During the second and fourth cycles, teacher candidates teach lessons using technology. Lessons are recorded and analyzed in focus groups by the mentor and teacher candidate. This type of activity allows both parties to reflect on their work. Liu et al. noted that mentor teachers often do not have the time to learn from each other, so it might be beneficial to build in time for them to share, reflect and learn from one another.

Providing a variety of professional development experiences for mentor teachers and teacher candidates may strengthen the skills of each population. Just-in-time coaching for mentors can also be helpful, and in one study (Tiba & Condy, 2021), teacher candidates indicated that workshops helped develop their confidence with technology.

Mentor programs in which new teachers are mentored by experienced teachers with effective interpersonal skills can lead to a shared understanding of effective teaching practices, the development of an inquiry approach, and opportunities for reflection (Beutel et al., 2017). Critical to such programs is the time and attention paid to the skill development of mentors around building relationships and establishing clear expectations about the role of mentors as colearners and coinquirers. In a mentor program discussed by Beutel et al., mentors participated in workshops, an online community of practice, and other activities that bolstered their understanding of their role in working with new teachers.

Conclusion

Providing teacher candidates with iterative opportunities to practice teaching and learning with technology is one of the essential conditions to Pillar 3 of technology infusion in teacher preparation. Such opportunities can be provided through clinical experiences in the PK-12 classroom, microteaching, simulations, or VR. A combination of these strategies can help to address the weakness of each model, as discussed in this article.

For technology infusion to be successful, teacher preparation programs need to work with their PK-12 colleagues to ensure each teacher candidate has the opportunity to practice teaching with technology. The teacher preparation field can no longer rely on an approach that places teacher candidates with random teachers willing to take them. Teacher educators need to find the best teachers to serve as mentors. To do this, we need to identify in-service teachers who are technology-savvy, who are exceptional mentors, who are reflective and able to explain to a novice teacher why they are choosing a specific technology and what factors they consider as they plan a lesson or unit. Only by locating, recruiting, and collaborating with these mentor teachers and school administrators can we hope to infuse and strengthen the practice pillar within teacher preparation. Resources to enable teacher preparation programs to strengthen Pillar 3 are provided in the appendix.

References

Allan, D. W. (1967). *Micro-teaching, a description*. Stanford Teaching Education Program, Stanford University, CA. https://files.eric.ed.gov/fulltext/ED019224.pdf

Anderson, S., Hahn, D., Hedenstrom, M., Schwartz, T. & Beaverson, S. (2015). Three best practices for 1:1. In D. Rutledge & D. Slykhuis (Eds.), Proceedings of SITE 2015--Society for Information Technology & Teacher Education International Conference (pp. 2203-2208). Association for the Advancement of Computing in Education. https://www.learntechlib.org/p/150306/

Arslan, A. (2021). Pre-service teachers' journey of "teaching" through micro-teaching: A mixed design research. *Education and Science, 46*(207), 259-283.

Beutel, D., Crosswell, L., Willis, J., Spooner-Lane, R., Curtis, E., & Churchward, P. (2017). Preparing teachers to mentor beginning teachers: An Australian case study. International *Journal of Mentoring and Coaching in Education, 6*(3), 164–177. https://doi.org/10.1108/ijmce-04-2017-0030

Borup, J., West, R.E., Graham, C.R., & Davies, R.S. (2014). The adolescent community of engagement framework: A lens for research on K-12 online learning. *Journal of Technology and Teacher Education, 22*(1), 107-129.

Bradley, E. G., & Kendall, B. (2014). A review of computer simulations in teacher education. *Journal of Educational Technology Systems, 43*(1), 3-12. https://doi.org/10.2190/ET.43.1.b

Bughin, J., Hazan, E., Lund, S., Dahlström, P., Wiesinger, A., & Subramaniam, A. (2018). *Skill shift: Automation and the future of the workforce*. McKinsey & Company.

CAST. (2018). *Universal design for learning guidelines: Version 2.2*. https://udlguidelines.cast.org/

Christensen, R., Knezek, G. Tyler-Wood, T., & Gibson, D. (2011). SimSchool: An online dynamic simulator for enhancing teacher preparation. *International Journal of Learning Technology, 6*(2), 201-220. https://doi.org/10.1504/IJLT.2011.042649

Clausen, J. M., Borthwick, A., & Rutledge, D. (2021). Teacher educator perspectives on technology infusion: A closer look using Q methodology. *Journal of Technology and Teacher Education, 29*(1), 5-43. https://www.learntechlib.org/primary/p/218585/

Clinical Practice Commission. (2018). *A pivot toward clinical practice, its lexicon, and the renewal of educator preparation*. American Association for Colleges of Teacher Education. https://aacte.org/resources/research-reports-and-briefs/clinical-practice-commission-report/

Davis, T. J., Merchant, Z., & Kwok, O-M. (2022). An examination of practice-based virtual simulations and pre-service mathematics teaching efficacy and outcome expectancy. *Education Sciences, 12*(4), 1-21. https://doi.org/10.3390/educsci12040262

Dexter, S., & Richardson, J. W. (2020). What does technology integration tell us about the leadership of technology? *Journal of Research on Technology in Education, 5*(1), 17-36. https://doi.org/10.1080/15391523.2019.1668316

Digital Learning Collaborative. (2018). *Online learning graduation requirements*. Digital Learning Collaborative. https://www.digitallearningcollab.com/online-learning-graduation-requirements

Digital Promise (2022). *Edcamp community*. https://digitalpromise.org/edcamp/

Eaton, M. (2020). *The perfect blend: A practical guide to designing student-centered learning experiences*. International Society for Technology in Education.

Ebersole, L. (2019). Preservice teacher experience with technology integration: How the preservice teacher's efficacy in technology integration is impacted by the context of the preservice teacher education program. *International Dialogues on Education Journal*, *6*(2). https://doi.org/10.53308/ide.v6i2.64

Ericsson, K. A. (2002). Attaining excellence through deliberate practice: Insights form the study of expert performance. In M. Ferrari (Ed.), *The pursuit of excellence in education* (pp. 21–55). Routledge.

Ferdig, R. E., Kosko, K. W., & Gandolfi, E. (2022). Using the Covid-19 pandemic to create a vision for XR-based teacher education field experiences. *Journal of Technology and Teacher Education, 30*(2), 239-252. https://www.learntechlib.org/p/221194/

Fisher, J., & Burrell, D. N. (2011). The value of using micro teaching as a tool to develop instructors. *Review of Higher Education and Self-Learning, 4*(11), 86-94.

Foulger, T. S. (2020). Design considerations for technology-infused teacher preparation programs. In A. Borthwick, T. Foulger, & K. Graziano (Eds.), *Championing technology infusion in teacher preparation* (pp. 3–28). International Society of Technology in Education.

Foulger, T. S., Graziano, K. J., & Borthwick, A. (2020, December 15). Developing technology excellence in teachers requires lots of practice. *EdPrep Matters*, American Association of Colleges for Teacher Education. https://edprepmatters.net/2020/12/developing-technology-excellence-in-teachers-requires-lots-of-practice/

Foulger, T. S., Graziano, K. J., Schmidt-Crawford, D., & Slykhuis, D. A. (2017). Teacher educator technology competencies. *Journal of Technology and Teacher Education, 25*(4), 413-448. https://www.learntechlib.org/p/181966/

Foulger, T. S., Wetzel, K., & Buss, R. (2019). Moving toward a technology infusion approach: Considerations for teacher preparation programs. *Journal of Digital Learning in Teacher Education 35*(2), 79-91. https://doi.org/10.1080/21532974.2019.1568325

Garrison, D. R., Anderson, T., & Archer, W. (1999). Critical inquiry in a text-based environment: Computer conferencing in higher education. *The Internet and Higher Education, 2*(2-3), 87-105.

Gomez, F. C., Trespalacios, J., Hsu, Y.-C., & Yang, D. (2021). Exploring teachers' technology integration self-efficacy through the 2017 ISTE Standards. *TechTrends*, *66*(2), 159–171. https://doi.org/10.1007/s11528-021-00639-z

Graziano, K. J., & Bryans-Bongey S. (2018). Surveying the national landscape of online teacher training in K-12 teacher preparation programs. *Journal of Digital Learning in Teacher Education, 34*(4), 259-277. https://doi.org/10.1080/21532974.2018.1498040

Graziano, K. J., & Feher, L. (2016). A dual placement approach to online student teaching. *Contemporary Issues in Technology and Teacher Education Journal*, *16*(4), 495-513. https://citejournal.org/volume-16/issue-4-16/general/a-dual-placement-approach-to-online-student-teaching

Grossman, P., Compton, C., Igra, D., Ronfeldt, M., Shahan, E., & Williamson, P. (2009). Teaching practice: A cross-professional perspective. *Teachers College Record, 111*(9), 2055–2100. https://doi.org/10.1177/016146810911100905

Hayes, A., Daughrity, L. A., & Ming, N. (2021). Approaches to integrate virtual reality into K-16 lesson plans: An introduction for teachers. *TechTrends*, *65*, 394-401. https://doi.org/10.1007/s11528-020-00572-7

Helmsing, M., Parker, A., Glaser, H., Zenkov, K., & Porter, A. (2022). Coaching cubed: Mentor teachers' perspectives on the exponential nature of supporting teacher candidates during uncertain times. *School-University Partnerships*, *15*(1), 1–20.

International Society for Technology in Education (2022a). *EdTech Policy Maps* https://www.iste.org/edtech-policy-maps

International Society for Technology in Education (2022b). *The ISTE standards.* https://www.iste.org/iste-standards

Jin, Y., Clausen, J. M., Elkordy, A., Greene, K., & McVey, M. (2023). Design principles for modeled experiences in technology-infused teacher

preparation programs. *Contemporary Issues in Technology and Teacher Education*, *23*(1). https://citejournal.org/volume-23/issue-1-23/general/design-principles-for-modeled-experiences-in-technology-infused-teacher-preparation

Kolb, L. (2016). *Learning first, technology second: The educator's guide to developing authentic lessons*. International Society for Technology in Education.

Kolb, L. (2020a). Frameworks that scaffold learning to teach with technology. In A. Borthwick, T. Foulger, & K. Graziano (Eds.), *Championing technology infusion in teacher preparation* (pp. 69–94). International Society for Technology in Education.

Kolb, L. (2020b). *Learning first, technology second in practice: New strategies, research and tools for student success*. International Society for Technology in Education.

Lamb, R., & Etopio, E. (2019). Preservice science teacher preparation using virtual reality. In K. Graziano (Ed.), *Proceedings of Society for Information Technology & Teacher Education International Conference* (pp. 162-167). Association for the Advancement of Computing in Education. https://www.learntechlib.org/primary/p/208478/

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge University Press.

Leithwood, K., Seashore Lewis, K., & Wahlstrom, K. (2004*). How leadership influences student learning*. The Wallace Foundation.

Liu, S.-H., Tsai, H.-C., & Huang, Y.-T. (2014). Collaborative professional development of mentor teachers and pre-service teachers in relation to technology integration. *Educational Technology and Society*, *18*(3), 161–172. https://www.jstor.org/stable/jeductechsoci.18.3.161

McLeod, S. (2018). *Harnessing technology for deeper learning*. Solution Tree.

McVey, M. (2020). The necessity of preparing teacher candidates to teach online. In A. Borthwick, T. Foulger, & K. Graziano (Eds.), *Championing technology infusion in teacher preparation* (pp. 113-128). International Society for Technology in Education.

Merod, A. (2022, March 2). *Grow-your-own teacher pipeline model gains steam*. https://www.k12dive.com/news/grow-your-own-teacher-pipeline-model-gains-steam/619672/

Mishra, P. (2019). Considering contextual knowledge: The TPACK diagram gets an upgrade. *Journal of Digital Learning in Teacher Education, 35*(2), 76-78. https://doi.org/10.1080/21532974.2019.1588611

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108*(6), 1017–1054. https://www.learntechlib.org/p/181966/

National Center for Educational Statistics. (2022). *Students with disabilities*. https://nces.ed.gov/programs/coe/indicator/cgg/students-with-disabilities

Nelson, M. (2017). The role of a mentor teacher's TPACK in prospective preservice teachers' intentions to integrate technology. *Journal of Technology and Teacher Education, 25*(4), 449-473.

Nicosia, M. (2021). *The pros, cons and lessons learned from schools that do virtual snow days*. Technology Solutions That Drive Education. https://edtechmagazine.com/k12/article/2021/01/pros-cons-and-lessons-learned-schools-do-virtual-snow-days-perfcon

Pendergast, D., O'Brien, M., Prestridge, S., & Exley, B. (2022). Self-efficacy in a 3-dimensional virtual reality classroom—Initial teacher education students' experiences. *Education Sciences, 12*(6), 368. https://doi.org/10.3390/educsci12060368

Polly, D., Byker, E. J., Putman, S. M., & Handler, L. K. (2020). Preparing elementary education teacher candidates to teach with technology: The role of modeling. *Journal of Digital Learning in Teacher Education, 36*(4), 250-265. https://doi.org/10.1080/21532974.2020.1795953

Project Tomorrow. (2021). *Empowering and engaging student voice to create equity in education: Five questions every K-12 education leader should ask today*. https://tomorrow.org/speakup/Blackboard-Five-Questions-K-12-Education-Leaders-Should-Ask-Today.html

Puentedura, R. R. (2013, May29). SAMR: Moving from enhancement to transformation. [Blog post]. http://hippasus.com/blog/archives/97

Quality Matters. (2022). https://www.qualitymatters.org/

Richardson, J. W., Sauers, N., & McLeod, S. (2015). Technology leadership is just good leadership: Dispositions of tech savvy superintendents. *AASA Journal of Scholarship and Practice, 12*(1), 11-30.

Richardson, J. W., Watts, J. L. D., & Sterrett, W. (2021). Challenges of being a digitally savvy principal. *Journal of Educational Administration, 59*(3), 318-334.

Shulman, L. S. (1998). Theory, practice, and the education of professionals. *Elementary School Journal, 98*, 511–526. https://www.jstor.org/stable/1002328

Slykhuis, D., Schmidt-Crawford, D., Graziano, K., & Foulger, T. (2020). Professional expectations for teacher educators: The teacher educator technology competencies (TETCs). In A. Borthwick, T. Foulger, & K.

Graziano (Eds.), *Championing technology infusion in teacher preparation* (pp. 95–109). International Society for Technology in Education.

Sprague, D., & Katradis, M. (2015). The transference between elementary preservice teachers' courses and technology use in education. In M. Neiss & H. Gillow-Wiles (Eds.), *Handbook of research on teacher education in the digital age* (pp 108-134). IGI Global

Sprague, D., Parsons, S., & Parker, A. (2020). Technology infusion in clinical experiences: The role of school-university partnerships in moving from coursework to clinical practice. In A. Borthwick, T. Foulger, & K. Graziano (Eds.), *Championing technology infusion in teacher preparation* (pp. 131–146). International Society for Technology in Education.

Sprague, D.R. & Wilbern, M. K. (2021). Going online during a national emergency: What college students have to say. *Computers in the Schools*. https://doi.org/10.1080/07380569.2021.1988316

Sprague, D.R., Williamson, J. & Foulger, T.S. (2022). Design guidelines for post-COVID era preparation programs: Action steps toward technology infusion. *Journal of Technology and Teacher Education, 30*(2), 177-187.

Sterrett, W. L., & Richardson, J. W. (2019). The change-ready leadership of technology-savvy superintendents. *Journal of Educational Administration, 57*(3), 227-242.

Sun, Y., Strobel, J., & Newby, T.J. (2016). The impact of student teaching experience on pre-service teachers' readiness for technology integration: A mixed methods study with growth curve modeling. *Educational Technology Research and Development, 65*, 597-629. https://doi.org/10.1007/s11423-016-9486-x

Sutton, S. R. (2011). The preservice technology training experiences of novice teachers. *Journal of Digital Learning in Teacher Education*, *28*(1), 39–47. https://doi.org/10.1080/21532974.2011.10784678

Tiba, C., & Condy, J. L. (2021). Identifying factors influencing pre-service teacher readiness to use technology during professional practice. *International Journal of Information and Communication Technology Education*, *17*(2), 149–161. https://doi.org/10.4018/ijicte.20210401.oa2

U.S. Department of Education, Office of Educational Technology, (2017). *Reimagining the role of technology in education: 2017 National Education Technology Plan update.* https://tech.ed.gov/files/2017/01/NETP17.pdf

UNESCO. (2022). *Comparing global university mindsets and student expectations: Closing the gap to create the ideal learner experience*. https://www.anthology.com/sites/default/files/2022-06/UNESCO-Anthology-Whitepaper-v1.5.pdf

van Ness, C., & Varn, J. (2021, July 29). *Governors prioritize expanding internet access for K12 students*. National Governors Association Commentary. https://www.nga.org/news/commentary/governors-prioritize-expanding-internet-access-fork-12-students/

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. Cambridge University Press. https://doi.org/10.1017/CBO9780511803932

Wenger E., McDermott R. A., & Snyder W. (2002). *Cultivating communities of practice: A guide to managing knowledge*. Harvard Business School Press.

Wenger-Trayner, E., & Wenger-Trayner, B. (2020). *Learning to make a difference: Value creation in social learning spaces*. Cambridge University Press. https://doi.org/10.1017/9781108677431

Wertsch, J. V. (1998). *Mind as action*. Oxford University Press.

Whiting, K. (2020, October 21). *What are the top 10 job skills for the future?* World Economic Forum. https://www.weforum.org/agenda/2020/10/top-10-work-skills-of-tomorrow-how-long-it-takes-to-learn-them/

Williams, M. K., Christensen, R., McElroy, D., & Rutledge, D. (2023). Teacher self-efficacy in technology integration as a critical component in designing technology-infused teacher preparation programs. *Contemporary Issues in Technology and Teacher Education*, *23*(1). https://citejournal.org/volume-23/issue-1-23/general/teacher-self-efficacy-in-technology-integration-as-a-critical-component-in-designing-technology-infused-teacher-preparation-programs

Williamson, J., & Moore, J. (2017). Technology integration in the induction years: The importance of PK-12 partnerships. In A. Borthwick, T. Foulger, & K. Graziano (Eds.), *Championing technology infusion in teacher preparation* (pp. 149–165). International Society of Technology in Education.

Appendix A
Program Design Resources

Competencies and Standards

Teacher Educators Technology Competencies (TETCs) - https://site.aace.org/tetc/

International Society for Technology in Education (ISTE) Standards

For Educators - https://iste.org/standards/iste-standards-for-teachers

For Students - https://iste.org/standards/iste-standards-for-students

For Education Leaders - https://iste.org/standards/iste-standards-for-education-leaders

Quality Matters Online Teaching Standards - https://www.qualitymatters.org/index.php/qa-resources/rubric-standards

Technology Integration Frameworks

Technological Pedagogical and Content Knowledge (TPACK) - http://www.tpack.org/

Substitution Augmentation Modification Redefinition (SAMR) Model - https://research.com/education/how-to-use-samr-model-in-designing-instruction

Triple E - https://www.tripleeframework.com/

4 Shifts Protocol - http://dangerouslyirrelevant.org/resources/4-shifts-protocol

Preparing for Online Instruction

Journal of Online Learning Research (JOLR) - a peer-reviewed journal devoted to the theoretical, empirical, and pragmatic understanding of technologies and their impact on pedagogy and policy in primary and secondary (K-12) online and blended environments. https://www.aace.org/pubs/jolr/

Community of Inquiry Framework - https://www.thecommunityofinquiry.org/coi

Building Partnerships with K-12 Schools

National Association of Professional Development Schools - https://napds.org/

American Association of College for Teacher Education: Clinical Practice Commission Report - https://aacte.org/resources/research-reports-and-briefs/clinical-practice-commission-report/

Professional Development Opportunities

EdCamps - https://digitalpromise.org/edcamp/

ISTE Podcasts - https://iste.org/professional-development/podcasts