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), 228-259.

Teacher Self-Efficacy in Technology Integration as a Critical Component in Designing Technology-Infused Teacher Preparation Programs

Mia Kim Williams
University of Wyoming

Rhonda Christensen
University of North Texas

Dennis McElroy
Graceland University

David Rutledge
New Mexico State University

This article focuses on factors related to supporting the development of teacher candidates' self-efficacy as critical components in designing technology-infused teacher preparation programs. Through a synthesis of relevant literature, the authors present information about elements influencing teacher self-efficacy in technology integration (TSEinTI) such as environments, attitudes, beliefs, intentions, support, policies, and resources. Findings describe the connection of TSEinTI to the experiences in teacher preparation programs through which teacher candidates gain the necessary knowledge, skills, and dispositions to enable the successful integration of technology in their future classrooms. Additionally, findings reveal the influence of program culture that can support teacher candidates' growth as they progress through a technology-infused approach to teacher preparation. The authors summarize recommendations for teacher preparation programs in the context of designing program-wide and program-deep technology-infused experiences to support the growth of candidates' teacher self-efficacy in technology integration.

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: (a) technology integration curriculum, (b) modeled experiences, (c) practice with reflection, and (d) technology self-efficacy. These pillars are essential components that work together to support successful program-deep and program-wide technology preparation.

Developing teacher self-efficacy in technology integration of teacher candidates within preparation programs is significant to ensure candidates become successful classroom teachers. Yet, to commence an explanation of teacher self-efficacy, it is important to understand self-efficacy, in general.

Self-efficacy refers to the belief that an individual can successfully fulfill a perceived role: the individual as an effective teacher. Self-efficacy is rooted in Bandura's (1977, 1986, 1993, 1997) social cognitive theory that supports individuals as their own change agents. Self-efficacy is defined as the belief an individual has in one's own abilities, specifically the ability to meet challenges and complete a task successfully. The theory is domain specific; for example, an individual might have self-efficacy in rock climbing, but not in driving a car. Identifying oneself as an accomplished rock climber means being successful at many smaller tasks associated with the sport, yet as individual elements improve, the level of self-efficacy is higher. According to Bandura (1993), self-efficacy is a good predictor of behavior. While self-efficacy is more broadly defined and applies to many areas of an individual's professional and personal experiences, this article focuses on how teacher self-efficacy impacts the integration of technology in the classroom.

Teacher self-efficacy (TSE), in general, has been defined as "judgment of his or her capabilities to bring about desired outcomes of student engagement and learning, even among those who may be difficult or unmotivated" (Tschannen-Moran & Hoy, 2001, p. 783). Research about TSE has consistently influenced the field of education since the mid-1970s (Armor et al., 1976). Zee and Koomen (2016) synthesized 40 years of TSE literature and reviewed its consequences at different levels of classroom ecology. The authors identified the importance of TSE for various classroom strategies, including instructional support, classroom organization, emotional support, students' achievement, students' motivation, and the well-being of all classroom participants, corroborating that TSE is relevant for the quality of classroom processes.

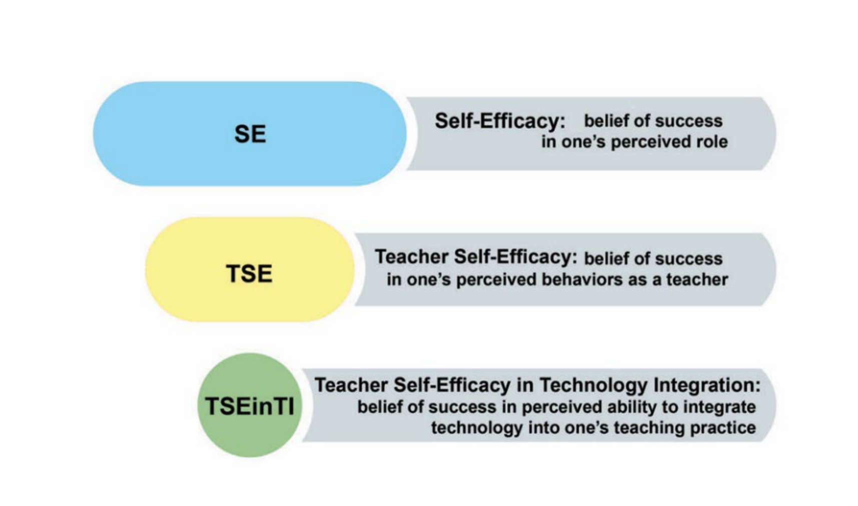
Teacher candidates are expected to be successful with these strategies as they enter the classroom. Additionally, today's educational landscape requires teachers to be equipped with continually evolving skills, knowledge, and dispositions to thrive in various digitally rich contexts (Gordon et al., 2022). The need to engage in a shifting educational landscape calls for teacher candidates to adapt to the inevitable inclusion of technology, and as recent experience has revealed, unpredictable changes that influence schooling (Hodges et al., 2020; Webb et. al. 2021; Williams et al., 2020).

To reach the goal of adapting to the changing role of technology in education, teacher preparation programs must focus on the development of teacher candidates' TSE in ways that are relevant to their future classrooms. Thus, technology integration becomes a key component of teacher candidates' overall self-efficacy in teaching future students.

Like the rock climber, teachers must be effective in many facets of teaching to develop TSE. For example, a high school teacher may have high TSE in facilitating a project in which students reflect on and share their learning; yet their TSE may be low regarding guiding a classroom discussion about controversial topics. This low TSE warrants development in guiding classroom discussions. Teacher candidates need to practice both facilitating project-based learning and guiding discussions to develop strong TSE during their teacher preparation program experience. The same expectation is true for the development of effective technology integration.

Technology self-efficacy has been defined as confidence in one's competence with technology (Christensen & Knezek, 2017) and is one important factor influencing the effectiveness of teaching with technology (Hoy et al., 2009). However, knowing how to use technology is not enough for effective integration into teaching and learning. Focusing on the development of teacher candidates' TSE in technology integration (TSEinTI) requires iterative and diverse opportunities for engagement with technology in various educational environments and contexts (Lee & Lee, 2014). When considering the development of teacher candidates, it is imperative that teacher preparation programs include building efficacy in technology integration (Albion, 2001; Hoy et al., 2009). Figure 1 illustrates types of self-efficacy related to teacher preparation.

Figure 1
Types of Self-Efficacy Related to Teacher Preparation



Note: Technology self-efficacy is a component of TSEinTI and not pictured separately.

Technology-infused teacher preparation programs are designed to provide repeated opportunities for teacher candidates to engage in learning experiences that promote TSEinTI (Foulger et al., 2019). While achieving the goal of technology infusion requires attention to infrastructure, leadership, and organizational processes (Clausen et al., 2019), the purpose of the infusion of technology throughout a teacher preparation program is to provide future teachers with the competence to integrate technology in meaningful ways into their classrooms.

This article synthesizes representative literature related to the components supporting teacher candidates' development of TSEinTI. We summarize teacher preparation program experiences and considerations for cultivating TSEinTI, introducing recommendations for teacher educators and program leadership who support the design of technology-infused teacher preparation programs intended to meet the evolving context of technology integration in classroom practices.

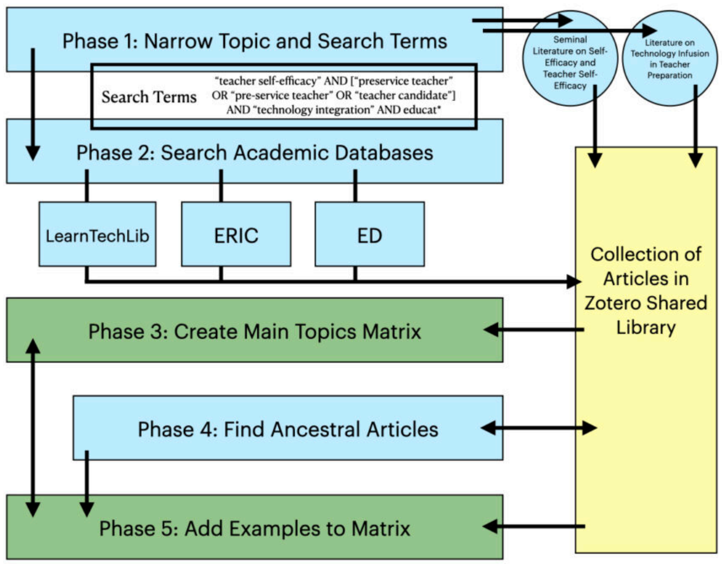
Method

This synthesis of relevant literature was conducted through adapting several approaches (Dickins & Weber Buchholz, 2022; Dixon-Woods et al., 2005; Ingram et al., 2006; Torraco, 2005) into a five-phase process. The literature synthesis centered on teacher self-efficacy in technology integration within teaching and learning with the intent to inform teacher preparation program designers. It was integrative in that we reviewed both empirical studies and practitioner articles (Russell, 2005; Torraco, 2005). Using a sequence of phrases (e.g., teacher self-efficacy, preservice teacher, technology integration) for identifying and collecting literature yielded articles summarizing concepts and theories (Dickins & Weber Buchholz, 2022; Torraco, 2005; Torronto & Remington, 2020) relevant to the topic of TSEinTI.

Our search of the literature provided both descriptive and practical examples, but we do not claim to have completed an exhaustive review of the literature on the topic. Adopting this approach allowed us to identify patterns and trends while translating the findings into evidence-based practices (Dickins & Weber-Buchholz, 2022; Dixon-Woods et al., 2005; Toronto & Remington, 2020) with the aim of recommending practices for teacher candidates' development of TSEinTI through their teacher preparation program experiences. Our five-phase approach, depicted in Figure 2, is followed by an explanation of each phase.

To guide the process and identify relevant literature, we first formulated the purpose of the inquiry, which was to synthesize the existing literature related to teacher candidates' TSEinTI and position that literature as leading to implications for designing technology infused teacher preparation programs that can promote development of TSEinTI. We individually searched for and identified related articles in order to determine appropriate search terms. Through several discussions and trial search attempts, we narrowed the search terms to yield the appropriate literature for this article (as recommended in Cooper, 1998). We also limited the database search to articles published in the past 10 years (2012-2022). This 10-year limit was identified because we wanted to present findings related to TSEinTI that were timely and relevant to current teacher preparation program contexts. Additionally, the 10-year limit built upon existing literature synthesizing 40 years of research regarding TSE (Zee & Koomen, 2016).

Figure 2
Five-Phase Process for Synthesis of Relevant Literature



Phase 1: Narrow Topic and Determine Search Terms

In this initial phase, we also determined seminal articles about self-efficacy and teacher self-efficacy. Current literature about technology infusion in teacher preparation programs informed the framework of the study. Zotero (2006), a shared reference management system, was used to create a library in which we housed the articles included in the synthesis.

Phase 2: Search Academic Databases

We used the following search term string: "teacher self-efficacy" AND ["preservice teacher" OR "pre-service teacher" OR "teacher candidate"] AND "technology integration" AND educat*. Articles from three databases, Educational Resources Information Center (ERIC) (n = 349), Learning and Technology Library (LearnTechLib) (n = 127), and Education Source (n = 75) were identified. These three databases were selected because each is relevant in the education and education technology fields and contained education and educational technology specific journals. Google Scholar (n = 904) was also searched, and results were compared with those from other databases; however, we noted many irrelevant articles and duplications, so it was excluded as an article source.

Following the initial search, one author entered all potential articles into a shared Zotero library. We then excluded duplicate articles, articles published in languages other than English, and articles originally published outside the search year parameters. We included articles if they were original research articles with quantitative or qualitative results, program evaluations, or research-based best practices written for a practitioner audience and included the search terms. As articles were reviewed, we also excluded articles addressing topics unrelated to teacher self-efficacy, teacher candidates' or teacher educators' development or that did not inform teacher preparation programs.

Phase 3: Create a Main Topics Matrix

We identified main topics related to the development of teacher candidates' TSEinTI from the articles and organized them into a matrix, with a main topic on the left and the representative publications on the right (as recommended in Dixon-Woods et al., 2005; Ingram et al., 2006). Some articles supported more than one main topic and were included in multiple rows of the matrix. Subfolders were created in the Zotero library to correspond with the main topics, including assessment, authentic experiences, competencies, equitable access, frameworks, integrated lessons, models of technology integration, reflection, and teacher educators. The main topics were refined during the synthesis process and were eventually divided into two categories: program components that develop teacher candidates' TSEinTI and program culture that values TSEinTI. Phases 3, 4, and 5 were a fluid process of creating and refining the main topics, which led to the structure for the article's narrative.

Phase 4: Find Ancestral Articles

We used additional articles found through the references of relevant articles. The ancestry method, or citation mining, was used when we required additional information or verification while synthesizing a main topic or locating examples (as in Torronto & Remington, 2020). All ancestorial articles were added to the appropriate subfolders in the shared Zotero library. The ancestorial articles represented earlier research on which the original relevant articles were based; thus, those found through the ancestry method are not limited to the 10-year publication date search parameter used in Phase 2. Including ancestral articles in the library provided depth and breadth to the literature. The final shared Zotero library (N = 225) included articles collected during Phases 1, 3, and 4 and informed the findings presented in this article.

Phase 5: Add Examples to Matrix

In addition to identifying main topics, we found examples illustrating each main topic from the articles in the shared Zotero library. These examples are included in the narrative, along with recommendations for program design.

Why Is Self-efficacy in Technology Integration Important?

The skills, knowledge, and dispositions teacher candidates develop through their teacher preparation program are intertwined with personal experiences and individual factors, such as personality traits. In-service teachers' TSEinTI and beliefs about their ability to impact student learning and achievement can drive their success in the classroom (Tschannen-Moran & Hoy, 2007). Much of the recent research that has been conducted with in-service teachers regarding technology self-efficacy can be applied to teacher candidates who will soon be their colleagues. In-service teachers who have high self-efficacy in technology integration also have the skills, knowledge, and dispositions to address the evolving demands of preparing PK-12 students for an uncertain future (Webber & Waxman, 2015). If teacher preparation programs are developing effective, future-ready teacher candidates, TSEinTI should be considered a critical element in the developmental process.

Knowledge Shifts of Today's Diverse Teacher Candidates

Current teacher candidates often have access to personal technology devices before attending a college or school of education and have developed technology skills, knowledge, and procedures that support communication, shopping, entertainment, and social interactions through digital platforms (Joshi et al, 2019; Szymkowiak, et al., 2021). These skills have been developed through lived experiences and, for some, through technology-infused PK-12 learning experiences. Teacher candidates live in and are often comfortable with today's technological world. However, significant disparity exists in the types of devices and amount of existing knowledge and previous practice teacher candidates possess (Christensen & Knezek, 2017).

Teacher candidates' experiences with technology prior to entering a teacher preparation program are an important consideration in the development of technology self-efficacy, which is their perceived skills and competence or perhaps misperceptions of their ability to use technology. Teacher preparation programs also play an important role in the future development of teacher candidates' self-efficacy in preparation for integrating technology into classroom practices (Pendergast et al., 2011).

Teacher candidates should be provided with the necessary tools required to develop high technology self-efficacy (Kent & Giles, 2017). A lack of access to technology and the internet can be a challenge for some teacher candidates due to the digital divide (Servon, 2002; Warschauer, 2007). The recruitment and retention of a more diverse teacher candidate population in teacher preparation programs will need to address the technology skills with which candidates enter. Nevertheless, there is no assurance candidates entering a teacher education program have the skills, knowledge, and dispositions to use technology successfully for teaching and learning.

The term "digital native," originally penned by Marc Prensky in 2001, described members of the upcoming generations as "native speakers" of the digital language of computers, video games, and the Internet. Purportedly, it was expected that these millennial children, who were born into the digital world, would have a natural comfort with all forms of information and communications technology (De Bruyckere et al., 2016). Kennedy and Fox (2013) investigated first-year undergraduates and found these students used a wide variety of digital technologies, but their primary use was for “personal empowerment and entertainment” (p. 76).

In addition, candidates entering teacher preparation programs are not always digitally literate in using technology to support learning. This is particularly evident when it comes to their use of technology as consumers rather than as creators of content for academic uses.

If teacher educators carefully design curriculum and include alternate forms of assessment that may integrate diverse media, they can create opportunities for developing teacher candidates’ digital literacies and expanding innovative and interesting learning environments. (Kennedy & Fox, 2013). It is important to differentiate access to and skills with technology from pedagogical practices with technology. A teacher candidate’s tech savviness for personal use or in their own learning is a foundation on which to build TSEinTI into teaching and learning, but their prior use of technology does not necessarily equip them to teach with technology.

Teacher Self-Efficacy and Successful Integration of Technology

Oliver and Shapiro (1993) found in-service teachers’ self-efficacy beliefs were indicators of success for technology integration. Additionally, teachers’ beliefs about technology impacted the integration of technology into their teaching practices (Al-Awidi & Alghazo, 2012; Compeau et al., 1999; Ertmer, 2005). These combined research findings provide a depth of insight into key ideas about how TSE influences successful technology integration (Compeau et al., 1999; Ertmer, 2005; Kwon et al., 2019, Oliver & Shapiro, 1993), and while the participants in many of the studies were in-service teachers, the insights can serve as a guide for designing activities to promote teacher candidates’ TSEinTI.

Bandura (1997) highlighted four types of influence that support the development of TSE, including (a) enactive mastery experiences, (b) vicarious experiences, (c) verbal persuasion, and (d) physiological and affective states. These four influence types provide a framework for ways hands-on experiences provide opportunities for success (mastery).

Additionally, Bandura’s work helps one realize observational experiences (vicarious) can be critical elements in the preparation of future teachers. Additionally, feedback, coaching, mentoring, and support (verbal persuasion along with physiological and affective states) influence the efficacy of teachers and should be provided in teacher preparation programs to develop positive TSE in a variety of digitally rich educational contexts, thus developing TSEinTI.

Bandura (1997) found that previous success with completing a task positively influenced an individual's self-confidence to succeed in a similar task. However, teachers with low self-efficacy may lack the motivation needed to improve. Because mastery and self-efficacy impact motivation, it is important for preparation program designers to focus on the factors that impact instructional self-efficacy in technology-rich environments (Elstad & Christophersen, 2017). Teachers and teacher candidates who have low self-efficacy in one area may avoid it and focus on something in which they feel confident (Artino, 2012). For example, if a teacher or teacher candidate has low TSEinIT, they will avoid implementing technology-integrated lessons or digitally rich contexts altogether.

Thus, an important component of a technology-infused program is to provide a variety of opportunities to develop TSEinTI throughout the program and in multiple contexts. Four methods to support in-service teachers and teacher candidates in developing their self-efficacy include designing instruction to enable candidates to (a) reflect on and learn from past successes or failures, (b) observe peers to thoughtfully consider successes or failures, (c) consider suggestions from other people, and (d) assess their stress level toward the task and identify ways to address that stress (Kwon et al., 2019).

Affective Influences on Development of Teacher Self-Efficacy

The development of TSEinTI does not happen in isolation. Just as the experiences and opportunities prior to and within the teacher preparation program influence its development, so do an individual’s attitudes, beliefs, and intentions. Teacher candidates’ attitudes toward learning with and about technology integration and taking risks in teaching are associated with TSEinTI. Teo and van Schaik (2012) found in their study that self-efficacy and attitudes influenced teacher candidates’ intentions to use technology. Kwon et al. (2019) measured the relationship between the integration of mobile technology and self-efficacy, beliefs, and ease of use. Of those three areas, only self-efficacy predicted the integration of technology.

Behavioral beliefs surrounding fidelity of integration influence attitudes and intentions. “Similarly, normative beliefs about perceived expectations of important reference groups such as other teachers or parents influence the subjective norms held by individuals about technology integration” (Buss, 2020, p. 197). Understanding various influences on teacher candidates’ TSEinTI development helps teacher educators purposefully include it in teacher preparation program design. Gathering data on these noncognitive variables can provide better understanding of these influences (Foulger et al., 2019) and will provide a specific understanding of the teacher candidates’ perceptions, which in turn, supports the design of purposeful activities.

While many barriers to technology integration may exist, internal barriers, which include attitudes, confidence, and beliefs, are often the most complicated to overcome (Ertmer et al., 2012). Additionally, overcoming internal barriers may be the most critical in integrating technology into the classroom. Researchers have found that teachers’ attitudes toward technology, their self-efficacy, their beliefs, their openness to change, and the perceived usefulness of the tools are among the factors that promote effective use of technology in the classroom (Christensen & Knezek, 2017; Kim et al., 2013).

Building TSEinTI Through Technology-Infused Teacher Preparation Programs

Based on our review of literature, we identified key design implications for policy and practice. The appendix shows strategies for the development of TSEinTI throughout teacher preparation programs. Recommendations for enhancing TSEinTI for teacher preparation programs are twofold: (a) design program components that develop teacher candidates TSEinTI and (b) grow a program culture that values TSEinTI.

Program components should reflect practical opportunities for teacher candidates to see and use examples and apply powerful applications of technology in teaching and learning contexts. Teacher candidates should make connections with experienced teachers who integrate technology into learning experiences. The culture of the program should enhance teacher educators' TSEinTI to support the development of teacher candidates through modeling and shared experiences.

Specific implications to be considered when designing technology-infused teacher preparation programs that could lead to higher teacher candidates' TSEinTI are described in the narrative that follows. Additional information in the appendix provides examples and references for more information to support the design of program-deep and program-wide infusion of technology to enable the development of TSEinTI in teacher candidates and teacher educators.

Developing a Program to Support Teacher Candidates' TSEinTI

Designing a teacher preparation program that supports teacher candidates' TSEinTI requires numerous opportunities for them to learn, practice, and plan technology integration to build the knowledge, skills, and dispositions that empower them to integrate technology into their future classrooms. Findings from the literature review revealed five components teacher preparation programs can integrate to support teacher candidates' TSEinTI:

- use of frameworks and models for technology integration,
- authentic experiences for candidate use of technology,
- opportunities for candidates to design technology-integrated lessons,
- opportunities for critical reflection, and
- assessment of candidate growth in self-efficacy in technology integration.

Adopting Models and Frameworks for Technology Integration

Integration models help provide a framework to understand and organize the necessary components for successful implementation of any program. One model, The Will, Skill, Tool, Pedagogy (WSTP) Model, is based on four components deemed necessary for the successful integration of technology into the classroom teaching and learning environment (Knezek & Christensen, 2016). The WSTP Model includes positive teacher attitudes toward technology (Will), proficiency with technology (Skill), access to the needed tools and infrastructure (Tool), and teaching practices that are conducive to promoting technology-infused teaching and learning (Pedagogy).

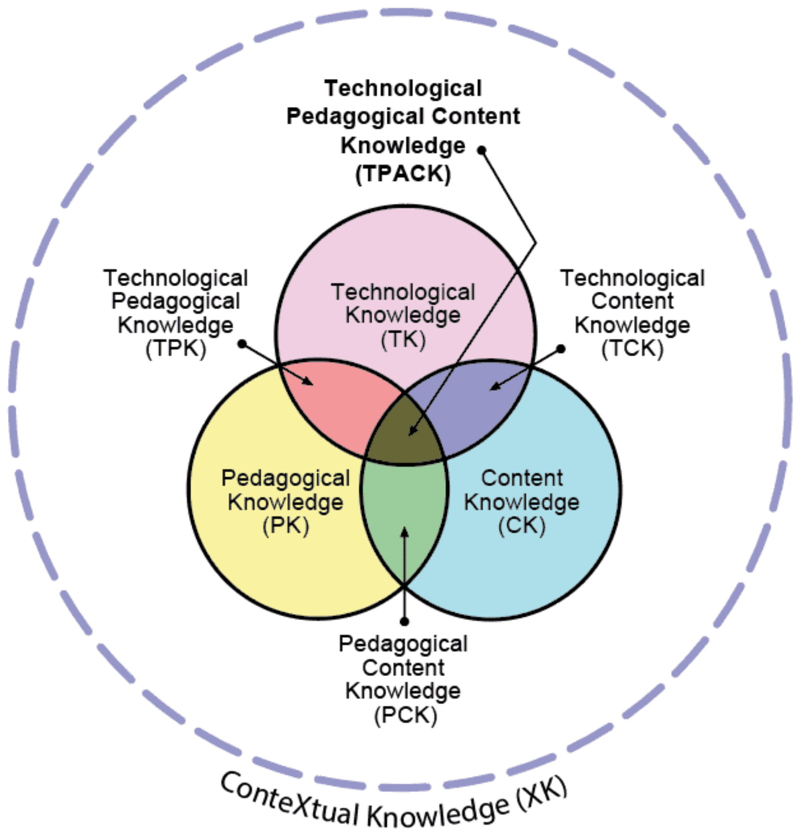
Technological pedagogical content knowledge (TPCK; also known as technology, pedagogy, and content knowledge, or TPACK) is a framework for technology integration intended to form a more integrated approach for three kinds of knowledge required for teaching: technology, pedagogy, and content (Thompson & Mishra, 2007–2008). It is illustrated in Figure 3.

In a study of 298 teacher candidates, data related to university support of technology, technology self-efficacy, perceived skills, and TPACK indicated technology self-efficacy to be a strong predictor of TPACK (Wang & Zhao, 2021). The researchers also found a significant positive correlation among university support, perceived competence, and self-efficacy as they related to technology. They concluded that to strengthen technology self-efficacy teacher preparation programs should provide opportunities to learn technology skills, provide access to the needed tools, and include ongoing guidance.

In addition, they concluded that being provided with models of successful technology integration, such as the TPACK Framework, was useful in improving TSEinTI. While TPACK represents three individual components (technology knowledge, pedagogical knowledge, and content knowledge), it is teacher candidates' development within the intersections of the distinct knowledge types (e.g., technological pedagogical knowledge, technological content knowledge, and TPCK) that can support higher self-efficacy beliefs about technology integration (Abbitt, 2021; Chai et al., 2019).

The Synthesis of Qualitative Data (SQD) Model was developed with the intention of providing an evidence-based model to inform teacher education programs. Tondeur et al. (2012) synthesized 19 qualitative studies, yielding 12 themes to create a model that includes components necessary to prepare teacher candidates to integrate technology effectively in their future classrooms. The SQD model contains three interrelated levels. All three levels are critical components of sustained, effective technology integration.

Figure 3
Technological Pedagogical Content Knowledge



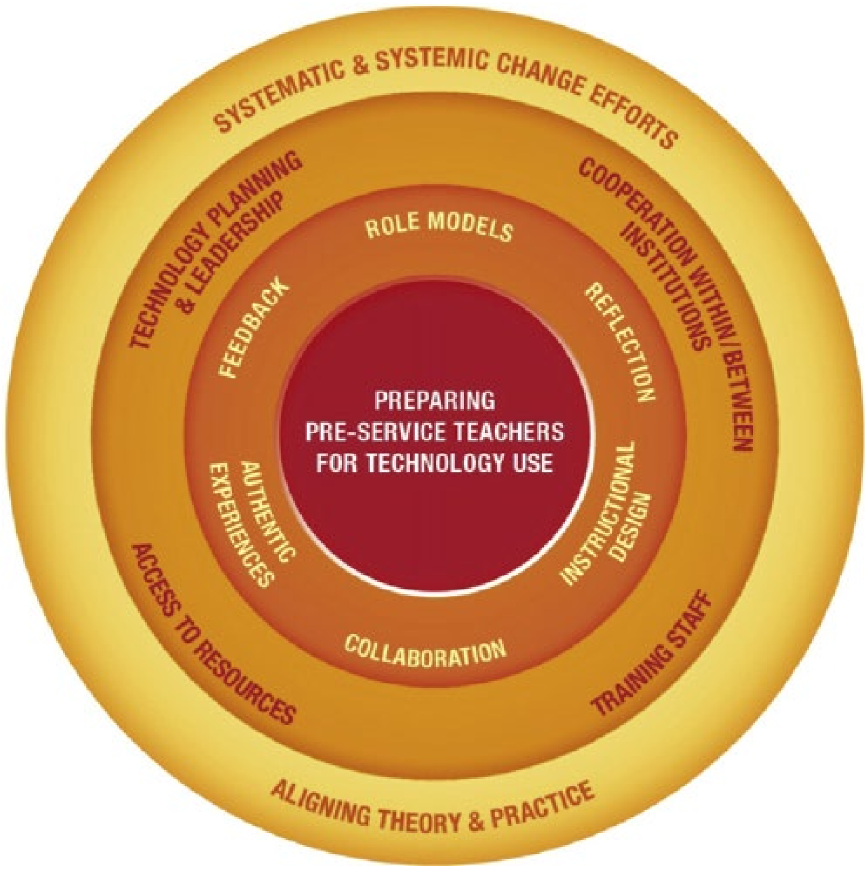
Note: Revised version of the TPACK image,
https://punyamishra.com/2018/09/10/the-tpack-diagram-gets-an-upgrade

The outside level of the model includes systematic and systemic change efforts that rely on evidence aligning theory to practice. Individuals tasked with making curricular decisions within the systems-level have the power to promote effective technology integration. The second level includes the components that support the teacher educator in the classroom with planning and leadership, resources, training, and professional development. In addition, the second level includes cooperation within and between institutions, which is a critical element in preparing teachers to use technology in their clinical experiences. The third level is connected to the experiences that need to be present in a teacher preparation program to ensure the candidates are prepared to use technology effectively and appropriately in the classroom.

As shown in Figure 4, these six strategies include role models, reflection, instructional design, collaboration, authentic experiences, and feedback.

Each of these strategies contributes to increasing candidates' TSEinTI and is discussed later in the article.

Figure 4
SQD Model to Prepare Teacher Candidates for Technology Use



Note: SQD Model to Prepare Teacher Candidates for Technology Use. Reprinted from "Preparing pre-service teachers to integrate technology in education: A synthesis of qualitative evidence," by J. Tondeur, J. van Braak, G. Sang, J. Voogt, P. Fisser, & A. Ottenbreit-Leftwich, 2012, *Computers & Education, 59*(1), 134-144. © Jo Tondeur, 2012. Reprinted with permission.

Experiences for Successful Integration of Technology

Successful technology-infused programs provide a variety of experiences and instruction to enhance the teacher candidates' TSEinTI, leading to effective technology-infused classroom practices. Connecting Bandura's (1997) four types of self-efficacy to the SQD model domains, candidate opportunities for designing instruction and participation in authentic field experiences enhances their TSEinTI and promotes mastery of their craft.

Research by Moore-Hayes (2011) focused on teacher candidate preparation for technology integration found that candidates valued completing a portion of their practicum in technologically advanced classrooms. These teacher candidates also emphasized the impact of mentorship by teachers experienced in effective teaching strategies, and the researcher concluded that "new teachers would have felt better prepared to include technology as part of a teaching strategy if they had been exposed to more authentic examples of successful technology integration during their teacher training" (p. 11).

Bandura's (1997) vicarious experiences can be provided by a variety of sources; an example significant to teacher candidates is role modeling from teacher educators leading preparation courses and supervising teachers in classroom experiences. In a study investigating the variables that increased TPACK, Wang and Zhao (2021) concluded that being provided with models of successful technology integration is useful for improving teachers' technology self-efficacy. An additional study related to ways modeling influences teacher candidates found that technology-integrated lessons designed by teacher candidates directly reflected the tools and practices previously modeled in their teacher preparation courses (Zipke et al., 2019).

The third of Bandura's (1997) four types of self-efficacy is verbal persuasion. Verbal persuasion can come from feedback and coaching provided to teacher candidates about a variety of classroom practices and dispositions. Ünal et al. (2017) studied elementary teacher candidates and their self-efficacy for technology integration; verbal persuasion in the form of feedback from mentor teachers was shown to have a significant effect on teacher candidates' self-efficacy in technology integration. Ünal et al. also noted that social persuasion and feedback from instructors were among the most influential factors contributing to the development of teacher candidates' self-efficacy for technology integration. Encouragement and feedback supported teacher candidates in developing and refining their beliefs about teaching and technology integration, as well as fostering positive feelings about that integration and ensuing instruction.

Bandura's (1997) physiological and affective states are chiefly related to attitudes and dispositions toward using technology. Yildiz Durak (2021) found that explicitly developing teacher candidates' beliefs and attitudes toward technology integration is one of the most significant variables impacting levels of self-efficacy. Additionally, research indicated that attitudes, beliefs, and dispositions may be improved through collaboration. This collaboration can take the form of teacher candidate and peer collaborations or teacher candidate and mentor teacher collaborations. The latter type of collaboration happens when teacher candidates share new tools and ways to teach with technology with their mentor teachers (Yey et al., 2021). Collaboration is a powerful form of teacher learning. The interactions and dynamics among members create distributed knowledge, which supports confidence in using technology and self-efficacy for technology use and integration (Yeh et al., 2021).

Impact of Designing Technology Integration Lessons

Self-efficacy for technology integration is a predictor of actual technology integration (Anderson & Maninger, 2007; Anderson et al., 2011). Research has suggested that teacher candidates need regular practice making connections between professional knowledge, technology, and instructional practice (Tondeur et al., 2012), as well as opportunities for reflection on those connections. Birisci & Kul (2019) found that designing instruction using technology for the classroom was a significant predictor of teacher candidate technology self-efficacy.

Wang & Zhao (2021) suggested that teacher candidates collect examples of technology integration, curating them into specific subject areas. This collection can provide teacher candidates with ideas and support when creating and designing future lessons. This repertoire of curating lesson ideas with the corresponding technology integration strategies is one step in scaffolding self-efficacy in teacher preparation programs. Additionally, the end goal in TSEinTI is to support teacher candidates with envisioning, procuring, developing, and providing PK-12 learner-focused content.

To this end, existing conceptual models add all-inclusive approaches for supporting teacher candidates in designing technology integrated instruction. Conceptual models related to technology integration identified through literature include (a) Substitution, Augmentation, Modification, Redefinition (SAMR; Puentedura, 2006); (b) Analysis, Design, Develop, Implement, Evaluate (Morrison, 2010); (c) TPACK (Mishra & Kholer, 2009); (d) Passive, Interactive, Creative – Replaces, Amplifies, Transforms (PIC-RAT; Kimmons et al., 2020); and (e) Engagement, Enhancement, Extension (Triple E; Kolb, 2020). Throughout the process of lesson preparation, teacher candidates become more effective decision makers, developing their beliefs about and attitudes toward learner expectations, instructional design for technology integration, and instructional practices.

The use of a repertoire and lesson planning models is only a first step in developing teacher candidates' self-efficacy. As self-efficacy represents a critical factor in teacher candidates' intention to integrate technology, it is important to develop not only technology integration skills and knowledge during teacher education programs, but also to attend to the affective dimension of self-efficacy.

Critical Reflection

The affective dimension can be addressed by supporting teacher candidates in developing positive feelings toward technology integration and working to alleviate teacher candidates' concerns. One method for doing this is through cases or vicarious experiences, which can build the observer's confidence and control, reduce anxiety, and increase self-efficacy with a particular task. However, teacher candidates need to move beyond the reality of *apprenticeship by observation* (Farrell, 2015; Lortie, 1975) to reflection as a process (Christopherson, 2019).

Self-efficacy development is dynamic. Supporting teacher candidates in the process of developing their TSEinTI in the physiological and affective states (Bandura, 1997) should include an action-reflection cycle (Naidoo & Naidoo, 2021). Action-reflection focusing on technology integration positions the teacher candidate's experience of instructional design and critical reflection alongside Bandura's (1997) four types of self-efficacy.

Critical reflection is a strategy that teacher candidates can use to cope with problems that may occur in the planning and implementation of technology-integrated lessons in the classroom (Yost, 2006). Research has shown that modeling and encouraging critical reflection throughout a teacher candidate's education experience resulted in meaningful changes in confidence and motivation. Rehmat and Bailey (2014) highlighted that explicit instructional support of teacher candidates and ongoing reflection into instructional practices led to positive changes in beliefs and behaviors relating to technology integration.

Assessing Progress in Developing Technology Self-efficacy

Being aware of one's own TSEinTI can be achieved through reflective practices and can be traced over time through repeated measures of self-efficacy using reliable inventories and scales. Accurately measuring levels of TSEinTI in teacher candidates is an important first step toward enhancing comfort level and confidence in integrating technology into their future classrooms. Although many measures of teacher self-efficacy can be found in the research literature, Table 1 includes a selection that has been used to document results related to teacher candidates' development of TSEinTI.

These measures have been shown to be reliable and valid instruments for use with teacher candidates, both as a baseline measure and as a pre-post measure following an intervention.

Researchers have indicated that measuring candidate development can inform both teacher candidates and teacher preparation programs of growth in TSEinTI throughout a candidate's program (Christensen, 2021; Christensen & Knezek, 2017; Foulger et al., 2021; Wang et al., 2004).

Teacher educators can also integrate other measures into candidates' experiences to gauge TSEinTI, using strategies such as digital learning portfolios, course assignments, interviews, and microcredentialing. Digital learning portfolios are a vehicle to compile, reflect on, and show growth over time via artifacts demonstrating technology integration. The act of creating a portfolio engages the teacher candidate in reflective practice and opportunities to showcase their work and learning. Digital learning portfolios have been used as an assessment tool and vehicle for developing TSEinTI (Kovalchick et al., 1998; Wetcho & Na-Songkhla, 2019). Assignments that allow teacher candidates to practice in safe environments, create and discuss interactively, or provide authorship opportunities reveal and develop TSEinTI (Byker et al. 2018; Rowston et al., 2021). Interviews or conferences with teacher educators create space for teacher candidates to talk through experiences and collaboratively build awareness of their TSEinTI with others.

Table 1
Teacher Self-Efficacy in Technology Integration: Teacher Candidate Assessment Tools

Measure	Measure Description	What It Assesses
Technology Proficiency Self-Assessment for 21st Century Learning (TPSA C21) (Christensen & Knezek, 2017)	34-item survey	teacher self-efficacy regarding skills for integrating technology into classroom teaching and learning
Technology Proficiency Survey for Educators (TPSE) (Christensen, 2021)	22-item, 3-scale survey	technology self-efficacy aligned with the ISTE standards for teachers; scales include 1. design, create and model learning with technology, 2. communicate and collaborate using technology, and 3. using technology to extend learning beyond the classroom
Intention to Teach with Technology (IT2) (Foulger et al., 2021)	56-item survey	behaviors, beliefs, attitudes, and intention to use technology in the classroom using The Decomposed Theory of Planned Behavior (Taylor & Todd, 1995)
Computer Technology Integration Survey (Wang et al., 2004)	21-item survey	participants' self-efficacy beliefs for technology integration
Technology Integration Confidence Scale (Brown, 2009, 2011)	25-item survey	participants' perception of confidence in completing tasks aligned with the ISTE Teacher standards

Buss (2020) discussed the benefits of conducting focus group interviews of teacher candidates for input to teacher preparation program development. Insights gained through conversations about lesson design, alignment to International Society for Technology in Education (ISTE) standards, and technology integration strengths and needs can inform teacher preparation course content and connections to field experiences (see also Kim et al. 2013).

Last, microcredentialing and badging can be both a way to promote teacher candidates' self-efficacy and trace it over time. "Digital badges promote increased self-efficacy through formative feedback and the ability to resubmit evidence in cases of inadequate performance" (Clausen, 2022, p. 278). Badges earned over time provide teacher candidates and teacher educators with ways to monitor technology integration and reflect incremental growth in TSEinTI. When making design decisions regarding technology infusion in teacher preparation programs, selecting a balance of measures that trace TSEinTI over time and that are embedded in or facilitate learning, provides opportunities to triangulate data and make sound assertions and decisions based on the data collected (Buss, 2020).

Influence of Program Culture in Creating TSEinTI

While TSEinTI occurs in individual candidates, the context and environment in which they are learning is instrumental in supporting their growth. Leadership in a teacher preparation program must develop buy-in from teacher education faculty members who have a direct impact on student learning. In addition, the infrastructure must provide and support the tools and access needed to integrate technology and development of technology self-efficacy. Findings from the literature indicate three elements of program culture essential to the support of teacher candidates' growth of TSEinTI:

- establishing expectations for teacher educators,
- providing infrastructure for equitable access,
- developing technology competency.

TSEinTI Expectations for Teacher Educators

Developing TSEinTI through a technology-infused teacher preparation program relies on collaborative efforts among institutional leadership, educational technology instructors, teacher educators, and local education agencies (Sprague et al., 2022). One key expectation for a successful technology-infused program is enhancing TSEinTI in teacher educators. Yet, research about teacher educators' self-efficacy in and attitudes about technology integration has limited representation in the literature (Ping et al., 2018). The recommendations for establishing expectations for teacher educators in the appendix are intended to bridge schisms across diverse content instructional practices while retaining individual instructors' abilities to draw on research that supports content-specific course design.

TSEinTI has the potential to deeply influence future classroom practices. Additionally, as teacher candidates gain confidence related to their digital skills there is an acknowledgment of strong connections to self-efficacy (Elstad & Christopherson, 2017). Multiple frameworks and models, such as TPACK (Thompson & Mishra, 2007), WSTP (Knezek & Christensen, 2016), SAMR (Puentedura, 2006), and SQD (Tondeur et al., 2012) provide conceptualizations of effective actions related to professional practice. The ISTE (2017) *Standards for Educators* and the Teacher Educator Technology Competencies (TETCs; Foulger et al., 2017) describe the desired level of practice and technology integration expected from effective in-service teachers and teacher educators. Professional standards help to ensure that teachers feel capable of creating rigorous, transformative, equitable, and technology-integrated learning experiences for PK-12 students.

Providing Infrastructure for Equitable Access

Providing adequate infrastructure and access to tools, resources, and connectivity is a common conversation when planning technology infusion in educational environments (Asher, 2009, Borthwick et al., 2020). There is a significant relationship between teachers' comfort and proficiency in using technology and the degree to which they implement the technology; thus, opportunities to build comfort with technology relies on access to tools (Schechter, 2013).

It is also challenging to integrate technology into educational environments that do not have reliable connectivity available. Colleges and schools of education and PK-12 schools' access to technology tools and connectivity affords technology integration and promotes its use throughout the curriculum in formal (e.g., classrooms and labs) and informal (e.g., common areas and libraries) learning environments (Leonard et al., 2021). Experiences interacting with classroom technologies and the perception of the level of difficulty to access and use technology influence TSEinTI (Schechter, 2013; Zilka, 2021).

Findings from Cardullo et al., (2020) also identified internet connection as a challenge and noted low TSEinTI where there was a lack of support and resources when teaching online. Yet, recognition of technology affordances such as ability to adjust to contextual shifts and to differentiate learning for students promoted higher TSEinTI.

Access to technology-infused opportunities is another necessary component to creating a program culture that values TSEinTI. Adopting a program-deep and program-wide mindset about technology integration across teacher preparation programs' coursework strengthens teacher candidates' TSEinTI through frequent access to technology-rich content and practice opportunities.

Ebersole (2019) found that the context of a teacher preparation program has an effect on teacher candidates' sense of self-efficacy related to technology integration. Teacher candidates should "encounter technology in conjunction with the pedagogical and content knowledge they need to master in order to eventually become innovative members of the larger community of practicing teachers" (p. 135). This requires not only access to standalone educational technology courses, but also subject-specific content and pedagogical approaches that model technology integration (Ebersole, 2019; Foulger et al., 2019; Koh & Divaharan, 2011; Ottenbreit-Leftwich et al., 2018). Researchers also claim that TSEinTI increases when teacher candidates have field experiences in technology-rich contexts and with savvy mentor teachers who can model integration and support technology-infused opportunities for teacher candidates' learning (Hammond et al., 2011; Liu, 2012; Sprague et al., 2023).

Developing Technology Competency

Proficiency with technology itself has also assumed an important role, whether technology is used to enhance instruction; used for communication between teachers, students, and parents; or used to assess student learning. Technology integration proficiency is a multifaceted attribute of an individual teacher that involves technology knowledge and skills, confidence in that knowledge and level of skill, attitudes, and pedagogical expertise, all merged together with content knowledge in a discipline (Mishra & Koehler, 2006).

The International Society for Technology in Education (2017) has created *Standards for Educators* to guide the skills needed to use technology in the 21st-century classroom. Twenty-first-century technology skills are those abilities that enable students to access, analyze, manage, synthesize, evaluate, create, and share information in a variety of forms and media that incorporate a global perspective. Accrediting agencies such as the Council for the Accreditation of Educator Preparation (ISTE-CAEP, 2016) have aligned their requirements regarding technology in teacher preparation programs with the ISTE standards. These ISTE standards are used by many teacher preparation programs to guide their teacher candidates' technology development.

As described in models presented earlier in this paper, there are multiple components that contribute to TSEinTI including attitudes, access to tools, as well as digital competency (pedagogical and technological skills; Knezek & Christensen, 2016; Mishra & Koehler, 2006). Digital competency includes both technology skills and pedagogical skills necessary to facilitate learning in a digital environment (Ogodo et al., 2021). The lack of these skills leads to limited use of technology in instructional practice, which contributes to a teachers' low TSEinTI (Anderson et al., 2011).

Conclusion

Teacher preparation programs that emphasize technology infused experiences provide teacher candidates many opportunities to develop their TSEinTI. Through such programs, teacher candidates are given space to practice and develop their TSEinTI and gain practical experience before entering PK-12 technology-infused contexts. A technology-infused teacher preparation program requires purposeful program design to create opportunities for teacher candidates to develop TSEinTI and create transformative learning experiences throughout the program. The design and implementation can be challenging and may require many stakeholders to participate. However, fostering the craft and practice of teacher candidates so they are well-prepared classroom teachers with the skills, knowledge, and dispositions to interact with their future PK-12 students successfully, in the continually evolving world, can be achieved with systematic design to develop teacher self-efficacy in technology integration – a critical component of teacher preparation.

References

Abbitt, J.T. (2021). An investigation of the relationship between self-efficacy beliefs about technology integration and technological pedagogical content knowledge (TPACK) among teacher candidates. *Journal of Digital Learning in Teacher Education, 27*(4), 134-143.

Al-Awidi, H.M., & Alghazo, I.M. (2012). The effect of student teaching experience on preservice elementary teachers' self-efficacy beliefs for technology integration in the UAE. *Educational Technology Research & Development, 60*, 923-941. doi: 10.1007/s11423-012-9239-4

Albion, P. (2001). Some factors in the development of self-efficacy beliefs for computer use among teacher education students. *Journal of Technology and Teacher Education, 9*(3), 321-347.

Anderson, S. E., Groulx, J. G., & Maninger, R. M. (2011). Relationships among preservice teachers' technology-related abilities, beliefs, and intentions to use technology in their future classrooms. *Journal of Educational Computing Research, 45*(3), 321-338.

Anderson, S. E., & Maninger, R. M. (2007). Preservice teachers' abilities, beliefs, and intentions regarding technology integration. *Journal of Educational Computing Research, 37*(2), 151-172.

Artino, A.R. (2012). Academic self-efficacy: from educational theory to instructional practice. *Perspectives in Medical Education, 1,* 76-85. doi: 10.1007/s40037-012-0012-5

Asher, G. (2009). Inadequate infrastructure and the infusion of technology into K-12 education. Distance learning. In P. L. Rogers, G. A. Berg, J. V. Boettcher, C. Howard, L. Justice, & K. D. Schenk, (Eds.), *Encyclopedia of distance* learning (2nd ed.; pp. 1155-1156). IGI Global. https://doi.org/10.4018/978-1-60566-198-8

Armor, D., Conroy-Oseguera, P., Cox, M., King, N., McDonnell, L., Pascal, A., & Zellman, G. (1976). *Analysis of the school preferred reading programs in selected Los Angeles minority schools* (Report No. R-2007-LAUSD). Rand Corporation.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*(2), 191–215. https://doi.org/10.1037/0033-295X.84.2.191

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Prentice-Hall.

Bandura, A. (1993). Perceived self-efficacy in cognitive development and functioning. *Educational Psychologist, 28*(2), 117-148.

Bandura, A. (1997). *Self-efficacy. The exercise of control*. Freeman and Company.

Birisci, S., & Kul, U. (2019). Predictors of technology integration self-efficacy beliefs of teacher candidates. *Contemporary Educational Technology, 10*(1), 75-93. doi.org/10.30935/cet.512537.

Borthwick, A., Foulger, T., & Graziano, K. (2020). *Technology infusion in teacher preparation: A framework for supporting future educators*. International Society for Technology in Education.

Bull, G., Spector, M. Persichitte, K., & Meiers, E. (2017). Reflections on preparing educators to evaluation the efficacy of educational technology: An interview with Joseph South. *Contemporary Issues in Technology and*

Teacher Education, 17(1). 11-16. https://citejournal.org/volume-17/issue-1-17/editorial/reflections-on-preparing-educators-to-evaluate-the-efficacy-of-educational-technology-an-interview-with-joseph-south

Buss, R. (2020). Evaluating technology infusion: Teacher candidate and program outcomes. In A. C. Borthwick, T. S. Foulger, & K. J. Graziano (Eds.), *Championing technology infusion in teacher preparation: A framework for supporting future educators* (pp. 69-94). International Society for Technology in Education.

Byker, E. J., Good, A. J., Miller, E., & Kissel, B. (2018). Multicultural media authorship: Using technology to create children's literature texts. *Multicultural Education, 25*(2), 22-25.

Cardullo, V., Wang, C.-h., Burton, M., & Dong, J. (2021), K-12 teachers' remote teaching self-efficacy during the pandemic. *Journal of Research in Innovative Teaching & Learning*, *14*(1), 32-45. https://doi.org/10.1108/JRIT-10-2020-0055

Chai, C.S., Jong, M. S.-Y., Yin, H.-B., Chen, M., & Zhou, W. (2019). Validating and modelling teachers' technological pedagogical content knowledge for integrative science, technology, engineering and mathematics education. *Educational Technology & Society, 22*(3), 61-73.

Christensen, R. (2021). Validation of a technology proficiency survey for educators. In E. Langran & L. Archambault (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference* (pp. 782-791). Association for the Advancement of Computing in Education.

Christensen, R., & Knezek, G. (2017). Validating the technology proficiency self-assessment for 21st century learning (TPSA C21) instrument. *Journal of Digital Learning in Teacher Education, 33*(1), 20-31. doi: 10.1080/21532974.2016.1242391

Christensen, R., Knezek, G., Tyler-Wood, T., & Gibson, D. (2011). SimSchool: An online dynamic simulator for enhancing teacher preparation. *International Journal of Learning Technologies*. *6*(2), 201-220.

Christopherson, K. (2019, May 14). "Apprenticeship by Observation" and the role of reflection. *Teachers on Fire Magazine*. https://medium.com/teachers-on-fire/apprenticeship-by-observation-and-the-role-of-reflection-9a263f1450b9

Clausen, J. (2022). Learning to fly: Development and design of micro-credentialing systems for an education preparation program in the absence of a required educational technology course. *TechTrends*. *66*(2), 276-286. https://doi.org/10.1007/s11528-021-00673-x

Clausen, J.M., Finsness, E.S., Borthwick, A.C., Graziano, K., Carpenter, J., & Herring, M. (2019). TPACK Leadership Diagnostic Tool: Adoption and implementation by teacher education leaders. *Journal of Digital Learning* *in Teacher Education, 35*(1), 54-72. https://doi.org/10.1080/21532974.2018.1537818

Compeau, D., Higgins, C.A., & Huff, S. (1999). Social cognitive theory and individual reactions to computing technology: A longitudinal study. *MIS Quarterly, 23*(2), 145-158.

Cooper, H.M. (1998). *Synthesizing research: A guide for literature reviews* (3rd ed.). Sage Publishing, Inc.

De Bruyckere, P., Kirschner, P., & Hulshof, C. (2016). Technology in education: What teachers should know. *American Educator, 40*(1), 12-18.

Dickins, K., & Weber-Buchholz, S., EdS. (2022). *Literature review and synthesis: A guide for nurses and other healthcare professionals*. Springer Publishing Company.

Dixon-Woods, M., Agarwal, S., Jones, D., Young, B., & Sutton, A (2005). Synthesising qualitative and quantitative evidence: A review of possible methods. *Journal of Health Services Research & Policy, 10*(1), 45-53.

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, 6*(2), 124-138.

Elstad, E., & Christophersen, K-A. (2017). Perceptions of digital competency among student teachers: Contributing to the development of student teachers' instructional self-efficacy in technology-rich classrooms. *Education Sciences, 7*(1). https://doi.org/10.3390/educsci7010027

Ertmer, P.A. (2005). Teacher pedagogical beliefs: The final frontier in our quest for technology integration? *Educational Technology Research & Development, 53*(4), 25-39.

Ertmer, P.A., Ottenbreit-Leftwich, A.T., Sadik, O., Sendurer, E., & Sendurer, P. (2012). Teacher beliefs and technology integration practices: A critical relationship. *Computers & Education, 59*(2), 423-435.

Farrell, T.S.C. (2015). Encouraging critical reflection in a teacher education course. In T.S.C. Farrell (Ed.), *International perspectives on English language teacher education*. Palgrave Macmillan, London. doi: 10.1057/9781137440068_3

Foulger, T.S., Buss, R.R., & Su, M. (2021). The IT2 Survey: contextual knowledge (XK) influences on teacher candidates' intention to integrate technology. *Educational Technology Research & Development, 69*, 2729–2760. https://doi.org/10.1007/s11423-021-10033-4

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/primary/p/181966/

Foulger, T. S., Wetzel, K., & Buss, R. 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

Gareis, C. R. & Grant, L. W. (2014). The efficacy of training cooperating teachers. *Teaching and Teacher Education, 39,* 77-88.

Gordon, D., Blundell, C., Mills, R., & Bourke, T. (2022). Teacher self-efficacy and reform: A systematic review. *The Australian Educational Researcher*. https://doi.org/10.1007/s13384-022-00526-3

Hammond, M., Reynolds, L., & Ingram, J. (2011). How and why do student teachers use ICT? *Journal of Computer Assisted Learning, 27*(3), 191–203. https://doi.org/10.1111/j.1365-2729.2010.00389.x

Hodges, C.B., Moore, S., Lockee, B.B., Trust, T., & Bond, M.A. (2020). The difference between emergency remote teaching and online learning. *EDUCAUSE Review*. https://er.educause.edu/articles/2020/3/the-difference-between-emergency-remote-teaching-and-online-learning

Hoy, A.W., Hoy, W.K., & Davis, H.A. (2009). Teachers' self-efficacy beliefs. In K. Wentzel & A. Wigfield (Eds.), *Handbook of motivation at school* (pp. 627-654). Routledge.

Imasiku, L., & Bacchiocchi, M. (2022). Virtual teaching rehearsals and repeated teaching simulations: Impact on pre-service teachers efficacy. In E. Langran (Ed.), Proceedings of Society for Information Technology & Teacher Education International Conference (pp. 1902-1905). Association for the Advancement of Computing in Education. https://www.learntechlib.org/primary/p/220971/

Ingram, L., Hussey, J., Tigani, M., & Hemmelgarn, M. (2006). *Writing a literature review and using a synthesis matrix.* Center for Excellence in Writing, College of Arts, Sciences & Education, Florida International University.

International Society for Technology in Education. (2017). *ISTE standards for educators*. https://www.iste.org/standards/for-educators

ISTE-CAEP standards for teacher educators. (2016). http://www.iste.org/standards/standards-in-action/caep

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

Joshi, S., Stubbe, D., Li, S., & Hilty, D. (2019). The use of technology by youth: Implications for psychiatric educators. *Academic Psychiatry*. *43*(1),101-109. doi: 10.1007/s40596-018-1007-2.

Kennedy, D., & B. Fox. (2013). 'Digital natives:' An asian perspective for using learning technologies. *International Journal of Education and Development Using Information and Communication Technology, 9*(1), 64-79.

Kent, A.M., & Giles, R. M. (2017). Preservice teachers' technology self-efficacy. *Southeastern Regional Association of Teacher Educators Journal, 2*6(1), 9-20.

Kim, C., Kim, M.K., Lee, C., Spector, J.M., & DeMeester, K. (2013). Teacher beliefs and technology integration. *Teaching and Teacher Education, 29*(1), 76-85.

Kimmons, R., Graham, C. R., & West, R. E. (2020). The PICRAT model for technology integration in teacher preparation. *Contemporary Issues in Technology and Teacher Education, 20*(1). https://citejournal.org/volume-20/issue-1-20/general/the-picrat-model-for-technology-integration-in-teacher-preparation

Knezek, G., & Christensen, R. (2016). Extending the will, skill, tool model of technology integration: Adding pedagogy as a new model construct. *Journal of Computing in Higher Education, 28*, 307–325. https://doi-org.libproxy.uwyo.edu/10.1007/s12528-016-9120-2

Koh, J. H. L., & Divaharan, S. (2011). Developing pre-service teachers' technology integration expertise through the TPACK-developing instructional model. *Journal of Educational Computing Research, 44*(1), 35–58.

Kolb, L. (2020). Frameworks that scaffold learning to teach with technology. In A. C. Borthwick, T. S. Foulger, & K. J. Graziano (Eds.), *Championing technology infusion in teacher preparation: A framework for supporting future educators* (pp. 69-94). International Society for Technology in Education.

Kolb, L., Kashef, F., Roberts, C., Terry, C., & Borthwick, A. (2018). Challenges to creating and sustaining effective technology integration in teacher education programs. *Paper Released at 2018 AACTE Annual Conference*, Baltimore, MD.

Kovalchick, A., Milman, N. B., & Elizabeth, M. (1998). Instruction strategies for integration technology: Electronic journals and technology portfolios as facilitators for self-efficacy and reflection in preservice teachers. *Technology and Teacher Education Annual,* 236-240.

Kwon, K., Ottenbreit-Leftwich, A.T., Sari, A.R., Khlaif, Z., Zhu, M., Nadir, H., & Gok, F. (2019). Teachers' self-efficacy matters: Exploring the integration of mobile computing devices in middle schools. *TechTrends, 63*, 682-692. doi: org/10.1007/s11528-019-00402-5

Lee, Y., & Lee, J. (2014). Enhancing pre-service teachers' self-efficacy beliefs for technology integration through lesson planning practice. *Computers & Education, 73,* 121-128.

Leonard, J., Mitchell, M., Barnes-Johnson, J., Unertl, A., Outka-Hill, J., Robinson, R., & Hester-Croff, C. (2018). Preparing teachers to engage rural students in computational thinking through robotics, game design, and culturally responsive teaching. *Journal of Teacher Education, 69*(4), 386–407. https://doi.org/10.1177/0022487117732317

Liu, S. H. (2012). A multivariate model of factors influencing technology use by preservice teachers during practice teaching. *Journal of Educational Technology & Society, 15*(4), 137-149.

Lortie, D. C., (1975). *Schoolteacher: A sociological study*. University of Chicago Press.

Mishra, P. (2019). Considering contextual knowledge: The TPACK diagram gets an upgrade. *Journal of Digital Learning in Teacher Education, 35*(2), 76–78.

Mishra, P., & Koehler, M. (2006). Technological pedagogical content knowledge: A Framework for teacher knowledge. *Teachers College Record, 108*(6). https://doi.org/10.1111/j.1467-9620.2006.00684.x

Moore-Hayes, C. (2011). Technology integration preparedness and its influence on teacher-efficacy. *Canadian Journal of Learning and Technology, 37*(3), 1-15.

Morrison, Gary R. (2010) *Designing effective instruction* (6th ed.) John Wiley & Sons.

Naidoo, K., & Naidoo, L.J. (2021). Designing teaching and reflection experiences to develop candidates' science teaching self-efficacy. *Research in Science & Technological Education*. https://doi.org/10.1080/02635143.2021.1895098

Olivier, T. A., & Shapiro, F. (1993). Self-efficacy and computers. *Journal of Computer-Based Instruction, 20*, 81-85.

Ogodo, J., Simon, M., Morris, D., & Akubo, M. (2021). Examining k-12 teachers' digital competency and technology self-efficacy during covid-19 pandemic. *Journal of Higher Education Theory and Practice*, *21*(11), 13-27.

Ottenbreit-Leftwich, A., Yin-Chan Liao, J., Sadik, O., & Ertmer, P. (2018). Evolution of teachers' technology integration knowledge, beliefs, and practices: How can we support beginning teachers use of technology? *Journal of Research on Technology in Education, 50*(4), 282-304, doi: 10.1080/15391523.2018.1487350

Pendergast, D., Garvix, S., & Keogh, J. (2011). Pre-service student-teacher self-efficacy beliefs: An insight into the making of teachers. *Australian Journal of Teacher Education, 36*(12), 46-57.

Ping, C., Schellings, G., & Beijaard, D. (2018). Teacher educators professional learning: A literature review. *Teaching and Teacher Education, 75*, 93-104.

Prensky, M. (2001). *Digital natives, digital immigrants*. https://www.marcprensky.com/writing/Prensky%20%20Digital%20Natives,%20Digital%2IImmigrants%20-%20Part1.pdf

Puentedura, R. (2006). *Transformation, technology, and education* [Blog post]. http://hippasus.com/resources/tte

Rehmat, A.P., & Bailey, J.M. (2014). Technology integration in a science classroom: Preservice teachers' perceptions. *Journal of Science Education and Technology, 23*(6), 744-755.

Rowston, K., Bower, M., & Woodcock, S. (2020). The lived experiences of career-change pre-service teachers and the promise of meaningful technology pedagogy beliefs and practices. *Education and Information Technologies, 25*(2), 681-705.

Russell, C. (2005). An overview of the integrative research review. *Progress in Transplantation, 15*(1), 8-13.

Schechter, A. (2013), Political and technology efficacy among millennials, ***Doctoral Dissertation***, University of Delaware.

Schmidt-Crawford, D.A., Lindstrom, D.L., & Thompson, A.D. (2020). Technology infusion: Program-deep, program-wide. *Journal of Digital Learning in Teacher Education, 36*(2), 82-83. doi: 10.1080/21532974.2020.1739490

Servon, L. J. (2002). *Bridging the digital divide: Technology, community and public policy*. Blackwell Publishing.

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). https://citejournal.org/volume-23/issue-1-23/general/technology-infusion-and-the-development-of-practice-the-quest-to-create-digitally-able-teachers

Sprague, D., Williamson, J., Foulger, T., Clausen, J., Mouza, C., & Milman, N. (2022). Meet the mavericks: Technology infusion in preservice teacher education. In E. Langran (Ed.), Proceedings of Society for Information Technology & Teacher Education International Conference (pp. 1124-1127). Association for the Advancement of Computing in Education. https://www.learntechlib.org/primary/p/220858/

Szymkowiak, A., Melovic, B., Dabic, M., Jeganathan, K., & Kundi, G. (2021). Information technology and Gen z: The role of teachers, the internet, and technology in the education of young people. *Technology in Society, 65*. doi: 10.1016/j.techsoc.2021.101565

Taylor, S., & Todd, P. (1995). Understanding technology information usage: A test of competing models. *Information Systems Research, 6*(2), 144–176.

Teo, T., & van Schaik, P. (2012). Understanding the intention to use technology by preservice teachers: An empirical test of competing theoretical models. *International Journal of Human-Computer Interaction, 28*, 178-188. http://dx.doi.org/10.1080/10447318.2011.581892

Thompson, A., & Mishra, P. (2007-2008, Winter). Breaking news: TPCK becomes TPACK! *Journal of Computing in Teacher Education, 24*(2), 64-67.

Tondeur, J., van Braak, J., Sang, G., Voogt, J., Fisser, P., & Ottenbreit-Leftwich, A. (2012). Preparing pre-service teachers to integrate technology in education: A synthesis of qualitative evidence. *Computers & Education, 59*(1), 134–144. https://doi.org/10.1016/j.compedu.2011.10.009

Tondeur, J., van Braak, J., Siddiq, F., & Scherer, R. (2016). Time for a new approach to prepare future teachers for educational technology use: Its meaning and measurement. *Computers & Education, 94*, 134–150. https://doi.org/10.1016/j.compedu.2015.11.009

Toronto, C. E., & Remington, R. (Eds.). (2020). *A step-by-step guide to conducting an integrative review*. Springer International.

Torraco, R. (2005). Writing integrative literature reviews: Guidelines and examples. *Human Resource Development Review, 4*(3), 356-367.

Tschannen-Moran, M., & Hoy, A. (2001). Teacher efficacy: Capturing an elusive construct. *Teaching and Teacher Education, 17*(7), 783-805.

Uluay, G. (2021).Digital simulation experiences of pre-service science teachers: An example of circuits. *International Journal of Progressive Education, 17*(3), 14-30.

Ünal, E., Yamaç, A., & Uzun, A. (2017). The effect of EHE teaching practice course on pre-service elementary teachers' technology integration self-efficacy. *Malaysian Online Journal of Educational Technology*, *5*(3), 39-53.

Wang, L., Ertmer, P.A., & Newby, T.J. (2004). Increasing preservice teachers' self-efficacy beliefs for technology integration. *Journal of Research on Technology in Education, 36*(3), 231-252. doi: 10.1080/15391523.2004.10782414

Wang, Q., & Zhao, G. (2021). ICT self-efficacy mediates most effects of university ICT support on teacher candidates' TPACK: Evidence from three normal universities in China. *British Journal of Educational Technology, 52,* 2319–2339. https://doi.org/10.1111/bjet.13141

Warr, M., Driskell, S., Langran, E., Mouza, C., & Schmidt-Crawford, D. (2023). Curriculum design for technology infusion requires a continuous collaborative process. *Contemporary Issues in Technology and Teacher Education, 23*(1). https://citejournal.org/volume-23/issue-1-23/general/curriculum-design-for-technology-infusion-requires-a-continuous-collaborative-process

Warschauer, M. (2007). A teacher's place in the digital divide. *Teachers College Record, 109*(14), 147–166. https://doi.org/10.1177/016146810710901408

Webb, C.L., Kohler, K.L., & Piper, R.E. (2021). Teachers' preparedness and professional learning about using educational technologies during the COVID-19 pandemic. Journal of Online Learning Research, 7(2), 113-132.

Webber, N., & Waxman, H. (2015). Changes in first year teachers' self-efficacy and confidence for integration technology into classroom instruction. In D. Rutledge & D. Slykhuis (Eds.), *Proceedings of SITE 2015 Society for Information Technology & Teacher Education International Conference* (pp. 3493-3499). Association for the Advancement of Computing in Education.

Wetcho, S., & Na-Songkhla, J. (2019). The different roles of help-seeking personalities in social support group activity on e-portfolio for career development. International Journal of Emerging Technologies in Learning, 14(2), 124-138.

Williams, M.K., Schroer, J.E., Gull, C., Miller, J.C., & Axelson, S. (2020). Creating a support network to sustain student-centered, active pedagogy in emergency online learning. In R.E. Ferdig, E. Baumgartner, R. Hartshorne, R. Kaplan-Rakowski, & C. Mouza, (Eds.), *Teaching, technology, and teacher education during the COVID-19 pandemic: Stories from the Field*. Association for the Advancement of Computing in Education.

Yeh, Y-F., Chan, K., & Hsu, Y-S. (2021). Toward a framework that connects individual TPACK and collective TPACK: A systematic review of TPACK studies investigating teacher collaborative discourse in the learning by design process. *Computers & Education, 171*. https://doi.org/10.1016/j.compedu.2021.104238

Yildiz Durak, H. (2021). Modeling of relations between K-12 teachers' TPACK levels and their technology integration self-efficacy, technology literacy levels, attitudes toward technology and usage objectives of social networks. *Interactive Learning Environments, 29*(7), 1136-1162.

Yost, D. S. (2006). Reflection and self-efficacy: Enhancing the retention of qualified teachers from a teacher education perspective. *Teacher Education Quarterly, 33*(4), 59-76.

Yun, H., Park, S. & Ryu, J. (2019). Exploring the influences of immersive virtual reality pre-service teacher training simulations on teacher efficacy. In K. Graziano (Ed.), Proceedings of Society for Information Technology & Teacher Education International Conference (pp. 2112-2116). Association for the Advancement of Computing in Education. https://www.learntechlib.org/primary/p/207938/

Zee, M., & Koomen, H. M. (2016). TSE and its effects on classroom processes, student academic adjustment, and teacher well-being: A synthesis of 40 years of research. *Review of Educational Research, 86*, 981-1015. https://doi.org/10.3102/0034654315626801

Zilka, G.C. (2021). Attitudes of preservice kindergarten teachers toward the integration of computers and the reduction of the digital divide in kindergartens. *Educational Technology Research and Development, 69,* 711–731. https://doi.org/10.1007/s11423-021-09982-7

Zipke, M., Ingle, J.C., & Moorehead, T. (2019). The effects of modeling the use of technology with pre-service teachers. *Computers in the Schools, 36*(3), 205-221.

Zotero. (2006). Zotero reference management system [open-source software]. Roy Rosenzweig Center for History and New Media. AGPL. https://www.zotero.org/

Appendix

Technology-Infused Teacher Preparation Program Design Implications

	Design Implication	Implementation Examples	Supporting References
Design Program Components that develop teacher candidates' TSEinTI	**Adopt frameworks and models for technology integration** that guide teacher candidates' pedagogical decisions	Teacher educators model technology implementation in their content areas. Teacher candidates work with mentor teachers who model technology integration in PK-12 contexts. Create a collection of examples of technology integration into specific subject areas to provide ideas and support for the creation and design of future lessons. Provide best-practice examples of technology infused lessons and lesson plans that are easily accessed. Use integration frameworks as guides for curriculum design.	Mishra, 2019; Puentedura, 2006; Sprague et al., 2023; Tondeur et al., 2012; Wang & Zhao, 2021; Warr et al., 2023; Zipke et al., 2019
	Build authentic experiences using technology collaboratively with field-based **mentor teachers**	Build partnerships between colleges and schools of education and school districts. Pair teacher candidates with mentor teachers who have high TSEinTI.	Jin et al., 2023; Moore-Hayes, 2011; Sprague, et al., 2023; Ünal, 2017; Warr et al., 2023
	Design technology integrated lessons throughout program courses and field experiences	Design lessons using integration frameworks, e.g., SAMR, TPACK, Triple E. Include technology-integrated lesson design requirements within method courses. Require technology-integrated lesson design opportunities within field experiences and/or student teaching. Position stand-alone technology course in the program sequence to facilitate lesson design opportunities. Align instructional design opportunities to the ISTE Standards for Students. Develop awareness of classroom contexts for technology infusion in PK-12 and Higher Education (Develop XK, ConteXtual Knowledge).	Birisci & Kul, 2019; Buss, 2022; Foulger et al., 2021; Kolb, 2018; Kolb, 2020; Mishra, 2019; Sprague et al., 2023; Warr et al., 2023; Yeh et al., 2021
	Provide reflective opportunities for teacher educators,	Use PIC-RAT framework. Integrate simulated experiences.	Bull et al., 2017; Christensen et al., 2011; Imasiku &

	teacher candidates, and mentor teachers	Teach in-class reflective practice. Employ models of reflective practice.	Bacchiocchi, 2022; Kimmons et al., 2020; Kolb et al., 2018; Sprague, et al., 2023; Uluay, 2021; Webb et al., 2021; Yun et al., 2019
	Assess teacher self-efficacy in technology integration throughout teacher preparation program	Measure self-efficacy of teacher candidates throughout the program using proven instruments and scales that include specific technology items. Conduct interviews or conferences with teacher candidates. Build learning portfolios that showcase abilities with technology integration.	Buss, 2020; Christensen, 2021; Foulger et al., 2017; Schmidt et al., 2009
Grow a Program Culture that values TSEinTI	**Establish expectations for teacher educators'** integration of technology in their courses	Make expectations for faculty explicit in hiring and promotion processes. Adopt ISTE Standards for Educators and Teacher Educator Technology Competencies (TETCs).	Anderson et al., 2011; Kolb et al., 2018; Ogodo et al., 2021
	Provide infrastructure for equitable access to technology tools (computers, apps, network connection, etc.)	Provide necessary tools and networks (computers, tablets, applications, software, AR/VR/AI, wi-fi, etc.) to teacher educators and teacher candidates. Provide access to technology-infused opportunities within the teacher preparation program. Provide access to technology-infused opportunities within field experiences.	Knezek & Christensen, 2016; Schechter, 2013; Schmidt-Crawford et al., 2020; Zilka, 2021
	Develop technology competency	Create a culture of program-wide competence in technology skills. Include stand-alone educational technology course in teacher preparation programs. Provide or request prerequisite experience with technology. Adopt ISTE Standards for Educators and Teacher Educator Technology Competencies.	Anderson et al., 2011; Elstad & Christopherson, 2017; Foulger, et al. 2017; Ogodo et al., 2021; Warr et al., 2023