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Preservice Teachers' Digital Literacy in Educator Preparation Programs: A Literature Review

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by

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Report

Presented to the Faculty of the Graduate School of
The University of Texas at Austin
in Partial Fulfillment
of the Requirements
for the Degree of

Master of Arts

The University of Texas at Austin
August 2023

Acknowledgements

I would like to thank my supervisor, Dr. Joan Hughes, for her invaluable advice to expand my intellectual horizons at every stage of my study. I would also like to thank Dr. Karen French for empowering me to be a more confident writer and a researcher.

Abstract

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The University of Texas at Austin, 2023

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As technology's potential to transform teaching and learning became clear, shared standards and expectations emerged for teachers to integrate in K-12 classrooms. However, despite the massive influx of classroom technology, there were few noticeable changes to the pedagogical development or curricular sequences. The purpose of this report is to provide a review of literature that explores how preservice teachers learn to conceptualize their own digital literacy during their teacher preparation. More specifically, this review investigates preservice teachers' learning about digital literacy conceptions in relation to how their learning experiences are embedded in and situated as part of learning activities and teaching practices with technology in teacher education coursework. The results of the literature review provide insight as to what learning opportunities teacher educators can provide when preservice teachers need to be prepared to understand and practice with technology for specific purposes and contexts in classrooms.

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Chapter 1: Introduction

This report explores the body of research related to preservice teachers' conceptions of digital literacy in technology integration. Chapter one introduces standards and expectations for teachers' technology use in classrooms and current practices with technology in K-12 classrooms. Chapter two reviews the research related to conceptions of teachers' digital literacy and how teacher candidates conceptualize their own digital literacy during coursework and field experiences. The chapter also looks at how preservice teachers learn to conceptualize their digital literacy during teacher education courses and how educator preparation programs influence preservice teachers' technology use and digital literacy.

In chapter three, I examine the practices that shape the way preservice teachers approach technology use in their future classrooms. The focus is to identify common themes regarding teacher candidates' digital literacy conceptions through technology-integrated activities and teaching practices in educator preparation programs. Finally, in chapter four, I discuss some implications and limitations of this review of the literature.

Standards and Expectations for Teachers to Use Technology

As technology's potential to transform teaching and learning became clear, shared standards and expectations emerged for teachers in K-12 classrooms. For example, the U.S. Department of Education [USDOE] (2022) suggested that teachers should create

opportunities for students to actively participate in learning activities with technology. The teachers' guide (USDOE, 2022) also encouraged all educators to facilitate learning progress of each student by using student data on digital devices, while safeguarding the use of technological tools during the instructional practices. In a similar vein, the International Society for Technology in Education (ISTE), outlined the knowledge, skills, and dispositions of teachers with more specific descriptions. To help students to become empowered learners, the ISTE Standards for Educators suggested that teachers should be a: (a) learner, (b) leader, (c) citizen, (d) collaborator, (e) designer, (f) facilitator, and (g) analyst (ISTE, 2017). The seven standards for teachers are as follows:

- as a learner, continually improve their practice by learning from and with others and exploring proven and promising practices that leverage technology to improve student learning;
- as a leader, seek out opportunities for leadership to support student empowerment and success and to improve teaching and learning;
- as a citizen, inspire students to positively contribute to and responsibly participate in the digital world;
- as a collaborator, dedicate time to collaborate with both colleagues and students to improve practice, discover and share resources and ideas, and solve problems;
- as a designer, design authentic, learner-driven activities and environments that recognize and accommodate learner variability;

- as a facilitator, facilitate learning with technology to support student achievement of the ISTE Standards for Students; and
- as an analyst, understand and use data to drive their instruction and support students in achieving their learning goals.

It is important to note that the focus of technology use in either USDOE's (2022) teacher guidelines or ISTE Educator Standards (2017) is not limited to adding technological devices to a lesson or allowing students to use digital media for completing assignments. Rather, teachers in the digital age are expected to teach with technology to create new opportunities for students and develop the professional capacity to support student learning. Such expectations for improving teaching through meaningful technology use are related to research findings over the years, which have acknowledged that not every technology use necessarily contributes to transformative learning. The following section discusses how technology is used in the current K–12 classrooms.

Current Practice with Technology in K–12 Classrooms

When technology is used in classrooms, how tools are used matters (Fullan, 2010; Selwyn et al., 2023). Technology use does not merely mean adding new devices or providing students with media to passively consume; rather, the use of technology can include creative, transformative opportunities for students to learn with technology (Kimmons et al., 2020).

In fact, according to a report of Organisation for Economic Co-operation and Development (OECD) (2020), only 5–21% of the videotaped classrooms, which taught the unit of quadratic equations in secondary school in eight countries—Chile, China, Columbia, Germany, UK, Japan, Mexico, Spain— incorporated technology to practice the students' knowledge of math concepts (i.e., Chile [5.1%], China [8.2%], Columbia [14.5%], Germany [10.0%], UK [21.2%], Japan [12.4%], Mexico [19.4%], Spain [10.6%]). Using this international data, the OECD shows that technology still remains "surprisingly absent from lessons" (OECD, 2020, p. 3) despite large investment and improved access to technology in schools.

Specific studies on teaching practice with technology in classrooms suggest that the level of technology integration might be somewhat limited to teacher-centered models and general purposes such as lesson planning, creating teaching resources, or projecting course content to students. For example, Polly (2014) investigated three elementary school teachers' use of technology during mathematics teaching. The study found that teachers' technology use primarily included whole-class activities and discussions rather than allowing students to use technology independently. In most lessons, the teachers focused on presentation technologies such as the document camera or interactive whiteboard to project tasks, quizzes, or computer-based activities that are not content specific. Polly also emphasized that the uses of technology by all three teachers were limited to mainly memorization types of tasks, in which students only had to type in or click on the correct answer, while there was no problem solving or higher-level thinking involved. This study

suggested that teachers need preparation for using technology as means to advance content-specific learning and teaching in more student-centered ways.

Pringle et al. (2015) also identified the limited uses of technology in content-based teaching. The study investigated science teachers' engagement in a yearlong technology integration initiative to enact teacher knowledge for technology integration (i.e., technological, pedagogical, and content knowledge [TPACK]) into inquiry-based science teaching practice. They found an increase in technology-integrated practice, including the use of hardware that requires more advanced knowledge. However, very little improvements occurred with content-specific pedagogy and inquiry-based science learning. This study suggested that increasing use of technology by teachers does not mean that teachers are using technology for content-focused teaching and learning, or making decisions for content-focused practice.

Similarly, in Tondeur et al. (2016), six beginning teachers used a wide range of technology tools in their practice. However, most chose the structured learning approaches over student-centered technology use. One fifth grade teacher participant used the interactive whiteboard on a daily basis, but the tool was used to show pictures to demonstrate or clarify concepts, or play a short video. Her teacher-centered pedagogical approach focused on content delivery with less emphasis on student-centered experimentation. In another example, both fourth and third grade teachers used in the classroom computers as a tutor for various foundational building exercises. However, their uses were mainly for drill and practice activities that support specific children's needs

rather than the pedagogical advances that technology can afford. The limited use of technology among study participants suggested that teachers require learning opportunities to go beyond teacher-centered models of integration and emphasize inclusion of more content-specific technology use.

Other studies have further suggested that even if teachers have positive beliefs about technology and are comfortable in using it, their use of technology does not necessarily align with strategies that are believed to facilitate students' knowledge construction. For example, Voet and De Wever (2017) conducted semi-structured interviews to examine how history teachers used technology in the context of inquiry-based learning activities through historical reasoning. Although most teachers held positive beliefs about technology, students' technology use during their interpretative inquiry activities remained limited to instances where technology served as a resource for the task, rather than providing cognitive or social support. The results suggested that teachers were not fully aware of the value of technology affordances to scaffold their students' learning activities, particularly for integrating technology for content-specific teaching.

Margolin et al. (2019) sampled 524 teachers from 26 schools about their perception of the value of technology use in lessons. 78% of teachers agreed that technology enhances student learning and that they have the ability to integrate technology with instruction. However, when they were asked how often they asked their students to engage in activities or assignments with the use of technology, 44–51% of teachers asked students at least monthly to engage in at least two different uses of technology for collaboration and critical

thinking, while 22–27% asked students at least monthly to engage in at least two different technology-based activities for communication and creativity. The study revealed that although teachers might be comfortable integrating technology into their teaching and use it frequently, their practice might not reflect the full benefits of educational technology to facilitate stronger critical thinking and collaboration among students.

Collectively, studies suggested that technology is mostly used by teachers for planning lessons, presenting information, or communication in ways that are associated with general teaching purposes in classrooms. In studies over a decade apart, Cuban (2001, 2013) found that despite the massive influx of classroom technology, there were few noticeable changes to the pedagogical development or curricular sequences. In his studies, Cuban found that exemplary teachers used technology in their daily lessons; however, he argued that their instructional approaches to integrate technology into the lesson (e.g., setting lesson goals, facilitating student engagement, or assessing learning outcomes) mirrored the previous teacher generation.

In similar work, Lei and Zhao (2007) provided further evidence that *how* technology is used bears more weight than *how much* technology is used. Their study investigated the impact of the quantity and quality of technology use on student learning outcomes, as measured by GPA, and they found that using technology in ways that are closely related to the subject matter from a constructivist approach can contribute to increases in student GPA; however, simply adding more technology or spending more time on computers can cause more harm than good in student learning.

Howland et al. (2012) also provided insights for understanding how technology can be used in classrooms. They argued that technology in a lesson should play a role in adding pedagogical support. More specifically, they described the characteristics of effective technology use that are: (a) active, (b) constructive, (c) intentional, (d) authentic, and (e) cooperative. What makes classroom technology use meaningful is the way it is used to shape students' learning activities and enhance their experiences. As they further describe, technology use can be meaningful when students "learn *with* the technology, not *from* it" (p. 5, emphasis in original). For example, setting a large display or new touch-screen surfaces did not automatically foster student collaboration; what led to the collaborative process in and out-of-classroom was a targeted instructional strategy for the content that utilized both the new technology-enabled real-time communication and students' needs in the learning process (Tissenbaum & Slotta, 2019). In a similar vein, when Chou and Block (2019) examined how teachers use technology, specifically, tablets, they found that student activities were mostly like a substitute for textbooks, such as reading online textbooks, filling out digitized worksheets, or searching relatively basic information on a web browser. On the other hand, when students answered what they would like to do with the devices, they preferred to have hands-on activities and small group activities by using maps, images of historical events, and interactive timeline videos. From the perspectives of teacher educators, supporting students' learning with technology suggests that teachers need to have the capacity to integrate technology in ways to support teaching and learning.

In summary, to meet technology's potential to transform teaching and learning in K-12 classrooms, ISTE Educator Standards and teacher guidelines have been introduced for all new teachers to come to their schools prepared. In essence, technology standards and expectations for teachers suggest that teachers should be able to rethink traditional approaches to teaching and take an active role in helping students become empowered learners in a changing world. However, using technology too often resulted in missed opportunities despite its educational potentials because of the way technological tools are used in lessons. Such challenges in technology integration imply the great need of preparation for teacher candidates to have knowledge and skills of how certain technologies can be used in content-specific instruction. The next section will further explore teachers' digital literacy as one's understanding of and practices with technology for specific purposes and contexts, and review teacher preparation to support preservice teachers' digital literacy conceptions to support student learning with technology.

Chapter 2: Literature Review

This chapter explores research into preservice teacher learning for digital literacy conceptions in educator preparation programs. The chapter begins by reviewing technology initiatives and state policies that aimed to foster teacher preparation for technology integration. The chapter also investigates definitions of digital literacy for teaching with technology, and I aim to discuss the key concepts of digital literacy that can support teachers practice technology integration. Also, I review studies that focused on preservice teacher learning for their digital literacy conceptions through a range of learning activities and teaching practices with technology in teacher education coursework.

Educator Preparation Programs and Future Teachers' Technology Use

Over the years, researchers and policymakers have emphasized the responsibility educator preparation programs have to ensure that every new teacher enters the classroom ready to teach with technology. Federal funding has tended to reflect this perspective. One early example is the Preparing Tomorrow's Teachers to Use Technology (PT3) grant, which was one of the federal funding programs that started to change the way teachers were prepared to use technology in classrooms. Between fiscal years 1999-2006, the PT3 program awarded $337.5 million in grants to colleges and universities, reaching 52 of the 100 largest educator preparation programs (USDOE, 2006).

According to Polly et al. (2010), which analyzed the PT3 with data-based documents including 11 peer-reviewed journal articles, five conference papers, and official

grant reports, they found there were two major approaches educator preparation programs initiated according to the PT3: (a) mentoring university faculty through workshops and individualized mentoring, and (b) promoting TPACK of both preservice teachers and in-service teachers followed by creating technology-rich instructional materials.

The PT3 project also led educator preparation programs to develop a set of model lessons to demonstrate technology use in a specific content area (Brush et al., 2003), design a program-wide professional development system and a mentoring program for faculty, graduate students, and cohort groups of preservice teachers (Mims et al., 2006), and provide faculty workshop and mini-grants for them to share the best practices of technology integration across campus (Strudler et al., 2003). However, there is little empirical data about the impact of PT3 initiatives on participants' technology integration skills or their beliefs about technology integration compared to the amount of funding or overall expectations of the project (Polly et al., 2010). Gonzales-Dholakia (2013) provided background information regarding the lack of documentation, explaining that the Department of Education disbanded the PT3 after funding the 2003-2004 projects, and this resulted in the requirement for submitting annual end of project reviews only for the first distributions of projects between 2000-2001.

Another example, the Enhancing Education through Technology (EETT) program is a federal government initiative from fiscal year 2002 to 2010 that encouraged educator preparation programs to ensure preservice teachers' technology-related preparation. The final report of the program (Bakia et al., 2009) reviewed that on a national level, EETT led

inputs to the educational system: (a) technology-related teacher technology development and (b) technology access, including hardware, software, and technical support. At the state level, states identified the required knowledge and skills for teachers to use technology for instructional purposes. As some of the key outcomes of the EETT, Bakia et al. noted that about half of the states (27) defined standards for teacher technology competency in 2006-2007, including technology-related coursework or other professional development to help teachers use technology for instruction.

States guided or requested adoption of technology standards into the curriculum and instruction of educator preparation programs. In fact, some standards have been used as performance indicators for teachers as well as preservice teachers, guiding curriculum and instruction in teacher education across U.S. states.

By May 2023, the national ISTE Educator Standards were adopted, adapted, or endorsed in eight different states: Connecticut, Georgia, Maryland, Rhode Island, New Hampshire, Texas, Utah, and Wyoming (ISTE, 2023). The levels of recognition—adoption, adaptation, endorsement of the standards—regarding the ISTE Educator Standards—varied across the states. For example, Maryland's Department of Education adopted the ISTE Standards for Educators as the state's educational technology standards. In Georgia, the state professional standards commission adapted elements of the ISTE Standards for Educators into rules for instructional technology in teacher education. In Connecticut, state boards endorsed the ISTE Standards for Educators, encouraging district-level use of the Standards. In Texas, the state endorsed the ISTE Educator Standards by

amending State Bill 1839 (SB 1839), which required all state-approved educator preparation programs to align their curriculum and instruction to the standards; and prepare teachers' digital literacy, which is defined as "the capacity to use, understand, and evaluate technology for use in education settings" (Texas Legislature Online, 2023). The next section reviews study findings on preservice teachers learning to teach with technology.

Preservice teachers learn how to teach with technology

Research in the field of teacher education has shown that teachers need preparation and support to learn to teach effectively with technology (Lawrence, et al., 2020; Kelly, 2015). Competence in integrating technology into lesson plans varies among preservice teachers (Baek & Sung, 2020; Kimm et al., 2022; Valtonen et al., 2019), and they often experience difficulties in using technology for a content-specific instruction (Kist & Pytash, 2015; Lemon & Garvis, 2016).

Furthermore, the kinds of teacher knowledge and skills specifically associated with technology use in classroom-based teaching are not identical to one's personal, general life nor simply transferred to the educational settings (Bannerman & O'Leary, 2021; Hughes, 2013). Even if preservice teachers are technologically knowledgeable, they may not have an understanding of how certain technologies can be used in content-specific instruction (Batane & Ngwako, 2017). Studies on preservice teachers' technology use show they do not possess sufficient proficiency to integrate technology into teaching, which suggests the need for support and preparation in using technology for educational purposes (Çetin,

2021; Kuo et al., 2022). The inaccurate assumption about the current or younger generation of preservice teachers may lead to overestimating their proficiency in technology use, while underestimating the importance of teacher preparation. The next section discusses the perceived barriers for preservice teachers to use technology and the impacts on practice.

Perceived Barriers for Preservice Teachers' Technology Use

Preservice teachers may face challenges impacting student learning with technology or meeting desired performance as educators (Brush et al., 2008; Kaimara et al., 2021). According to Ertmer (1999), two forms of barriers are related to technology use in classrooms: first-order (external) and second-order (internal). It is important to note that these perceived barriers can influence preservice teachers' intentions to use technology.

For example, first-order barriers involve hurdles that are external to a teacher's control, including time, access to technology, opportunities for professional development, resources, administrative support, and facilities (Goktas et al., 2009; Phelps et al., 2021). In one study, when a group of preservice teachers noticed that there were limited classroom technology resources, the perceived barriers led them to take a critical view of technology and to be skillful in using the tools within the limited resources (Emre, 2019). Second-order barriers include internal factors such as teachers' attitudes, confidence in using technology, and their beliefs in the usefulness of technology use in classrooms. These second-order barriers often relate to a lack of knowledge or ability in using classroom technology (Hramiak & Boulton, 2013). Second-order barriers are often considered to be

more difficult to overcome than first-order barriers since they are related to the fundamental makeup of a teacher professional (Francom, 2016), and formed as a consequence of instructors' reflection on their own teaching practice (Sánchez-Prieto et al., 2019).

Other researchers have identified third-order barriers, the element of design-thinking that coordinates strategic and practical approach to technology use. Tsai and Chai (2012) argue that design thinking seeks "to change and improve current situations and create what is desired" (p. 1058), and a lack of design thinking skills may lead to difficulties in re-organizing and creating learning materials or adapting to the instructional needs for different contexts and student dynamic. For example, preservice teachers in Bower et al. (2020) valued learning experiences with virtual reality. However, having design issues (technical skills, ideas for pedagogically meaningful tasks) constrained intentions to use virtual reality and visualization. Studies focused on the impact of design thinking and using the skills to support preservice teachers in technology use continue (Baran & AlZoubi, 2023; Calavia et al., 2023). In all, the presence of barriers and their influences on teaching practice suggest that it is crucial to support preservice teachers with quality preparation and learning opportunities in teacher education. The following section will discuss teachers' digital literacy as a key for understanding their use of technology in teaching.

Understanding Digital Literacy

When Paul Gilster coined the term digital literacy, he defined it as "the ability to understand and use information in multiple formats from a wide range of sources when it

is presented via computers" (Gilster, 1997, p. 1). His definition suggests that digital literacy enables an individual to think critically about information across new media, more so than the technical skills needed to use digital media and technology. In Bawden's (2008) definition, digital literacy is identified as the ideas and mindsets needed to access and evaluate new forms, sources, and contexts of information that include more than mere technology skills for any particular technology. In common, both Gilster's and Bawden's definitions imply that digital literacy requires the cognitive skills to make meaning in different modes of digital technology and different contexts of technology use.

Aligned with the focus on defining digital literacy as higher-order thinking skills to make meaning through the use of technology, the American Library Association's (ALA) Digital Literacy Task Force defined digital literacy as "the ability to use information and communication technologies to find, evaluate, create, and communicate information, requiring both cognitive and technical skills" (ALA, 2011). Some of the key characteristics of having digital literacy skills described by the ALA as follows:

- Is able to use diverse technologies appropriately and effectively to retrieve information, interpret results, and judge the quality of that information;
- Understands the relationship between technology, life-long learning, personal privacy, and stewardship of information
- Uses these skills and the appropriate technology to communicate and collaborate with peers, colleagues, family, and on occasion, the general public

- Uses these skills to actively participate in civic society and contribute to a vibrant, informed, and engaged community.

The ALA's definition and descriptions of digital literacy extended an individual's knowledge in locating information or applying thinking skills into one's endeavors to make meaning with digital resources and opportunities for learning, participating in a community, and staying engaged in a civic life. Over the years, various perspectives have been presented to describe digital literacy, yet the most essential factor capturing the concept concerns understanding what technology use means and how it can be useful to achieve one's own learning and living. Martin and Grudziecki (2006) treat digital literacy as a life skill, which has the potential to foster an ongoing process of individual development toward becoming "a whole person" with and through the use of technology in the digital age.

In all, the term digital literacy describes the knowledge and skills all individuals need to critically, creatively, and safely use digital technologies. Digital literacy emphasizes the importance of one's understanding of and practices with technology for specific purposes and contexts, particularly what the use of technology means and how it helps in achieving goals in one's learning, work and life. Following sections discuss what teachers' digital literacy means as teacher knowledge and skills for integrating technology into a subject matter and specific contexts of teaching and learning.

Teachers' Digital Literacy

Applying these notions of digital literacy to the specific context of teaching suggests that teachers' digital literacy refers to the knowledge and skills they need to understand and use technology for specific purposes and in teaching and learning contexts. In this sense, teachers' digital literacy consists of the following skills: (a) the ability to make meaning in different modes and formats of technology to create learning opportunities, and (b) a set of socially organized practices to improve teaching and learning with technology.

Making Meaning with Technology to Create Learning Opportunities

One of the distinctive features of teachers' digital literacy might be described as the skills to make meaning with technology to create learning opportunities. For example, Scribner and Cole's (1981) research serves as a foundational study for understanding teachers' digital literacy. They treat literacy as a set of skills that practices "not simply knowing how to read and write a particular script, but applying this knowledge for specific purposes in specific contexts of use" (Scribner & Cole, 1981, p. 236). With a focus on literacy as a set of skills to meet certain goals within a given context, using Scribner and Cole's framework that being digitally literate enables teachers to understand and practice technology use in specific educational contexts.

Teachers' digital literacy opens up opportunities for teaching practices that meet emerging needs and challenges (Brevik et al., 2019). A broader theoretical explanation for

the nature of digital literacy also comes from scholarly work in the New Literacies Studies (NLS). According to the New Literacy Studies (NLS) (Lankshear & Knobel, 2008), which is a body of scholarly work that investigated new types of literacy using both print and non-print texts, digital literacy involves skills related to the written language, and includes the techniques of multimodal language use and meaning-making. Leu et al. (2013) explained that the functions of literacy are changing and shaped by society, which now necessitates multiple literacies to read and write and make meaning from the new modes and formats of communication and knowledge development. This approach moves beyond the traditional view of literacy, introducing the concept of *new literacies* that involve the knowledge, skills, and dispositions needed for comprehension and communication with digital media and technology including 21st-century skills, media literacy, multimodal literacy, information literacy, and digital literacy (New London Group, 1996; Lankshear & Knobel, 2008). With these backgrounds, teachers' digital literacy includes the ability to recognize different modes and formats of digital media and technology and apply this knowledge to create learning opportunities through the use of technology.

Socially Organized Practices That Improve Teaching and Learning with Technology

Another distinctive nature of teachers' digital literacy relates to a set of socially organized practices to improve teaching and learning through technology. Focusing on the meaning of literacy as a social practice in cultural contexts, Street (2003) argued that literacy can best be understood as a practice that is always embedded in and dependent on

specific local contexts shaped by diverse groups of people. Street's view of literacy highlights the influence of language use within a larger social, cultural, and institutional context. Gee (2012) suggested that literacy serves as "an identity kit to play the role" (p. 152), which manifests as "*ways of recognizing and getting recognized* as certain sorts of *whos* doing certain sorts of *whats*" (p. 153, emphasis in original). These perspectives suggest that teachers' digital literacy is situated in the ways of recognizing technology use in classrooms and plays a key role in constructing their professional identities as teachers.

Phillips (2016) pointed out that teacher knowledge rarely stands alone as mere skills, nor is it decontextualized; instead, it is contextually situated or even influenced by the culture in which teacher learning happens. In his case study of teachers' technology use, one teacher participant's technology use knowledge development was revealed through her relationship with the near-peers in a professionally bounded group. Phillips noted that her desire to be identified as a competent, professional member of the group led her to be aware of technology standards and to develop technological knowledge in ways aligned with the group's joint enterprise in technology-supported learning.

With these backgrounds, teachers' digital literacy incorporates the skills that enable teachers to make meaning with technology for creating learning opportunities to meet specific contexts of technology use. The concept also suggests that teachers' digital literacy is the socially organized practices to improve teaching and learning, shaped by observed models, recognized expectations, or perceived barriers regarding technology use in classrooms.

Perceptions of Teachers' Digital Literacy

To further conceptualize teachers' digital literacy and support the development of digital literacy, researchers have proposed models and frameworks with specific focus and needs. One of the conceptual models, Hague and Payton (2011) outlines eight components of digital literacy development: functional meaning making, critical thinking, creativity, collaboration, finding and selecting information, social and cultural awareness, effective communication, and e-safety (See Table 1). It is important to note that digital literacy as desired reflects the grand theory of NLS, which views literacy as the socially organized ways of what people do with the information and media beyond reading and writing (Leu et al., 2013; Gee, 2012).

Other researchers have incorporated Hague and Payton's digital literacy components into their surveys to measure and analyze the levels of preservice teachers' digital literacy. For example, Shively and Palilonis (2018) found that most elementary preservice teachers in their study were not even aware of digital literacy until they attended workshops, which introduced digital literacy and specific examples of each component of digital literacy in the elementary education curriculum. In Ata and Yildirim's (2019) survey results, preservice teachers had high and positive perceptions of digital literacy. However, the results also revealed that some participants believed that they had a variety of skills as well as a range of levels in digital literacy. More specifically, Ata and Yildirim noted that the preservice teachers' perceptions relating to digital literacy may be concentrated in usefulness and benefits of technology use rather than the tools' pedagogical values, lacking

the refined skills for teachers to select the most appropriate technological tools to meet teaching goals and evaluate the outcomes of teaching with technology.

Table 1. Components of Teachers' Digital Literacy (Hague & Payton, 2011)

Components	**Descriptions**
Functional skills	Exhibiting skills in operating digital tools such as hardware, software, productivity software, learning management system, online assessment tools
Creativity	Possessing an ability to create digital content including producing short videos or visual storytelling, posting a picture with a description on social media, using blogs
Critical thinking and evaluation	Reinforcing critical thinking and evaluation by asking students thought provoking and challenging questions, encouraging discussion and analysis of ideas
Cultural and social understanding	Employing digital technologies for broadening cross-cultural understanding; asking students to repurpose a piece of media for a different culture or audience
Collaboration	Encouraging a mutually supportive and help in groups; editing texts collaboratively through a wiki online space or shared documents; having virtual presentation to support group reflection and progress
The ability to find and select information	Showing an ability to find, evaluate, and select information online; discussing plagiarism with students including online music, images, videos
Effective communication	Having an ability to repurpose information and contextualize for the targeted students; to carefully consider the images and the meanings they infer in the teaching materials.
E-safety	Safeguarding student data and privacy; being aware of unsecured websites, scamming, cyberbullying, digital copyright, and plagiarism issues

In a similar way, more than half of the participating preservice teachers in Peled (2020) reported a range of perceptions relating to their own digital literacy. Peled found an overall high level of digital literacy in all areas of suggested digital literacy such as: data collection, evaluation of data, data management, data processing, teamwork, integrity awareness, and social responsibility. However, Peled noted that preservice teachers may perceive themselves less prepared for critically analyzing information or higher-order problem solving. Both Ata and Yildirim's and Peled's studies showed there can be a difference between preservice teachers' self-perceptions and actual implementation of digital literacy practices, and ultimately suggest the gap needs to be addressed through teacher education. The next section will review research into teachers' digital literacy as technological knowledge and skills for technology integration.

TPACK and Digital Literacy

Technology-related teacher knowledge has been identified as a critical factor in how teachers use technology in teaching and learning (Belo et al., 2016; Ertmer & Ottenbreit-Leftwich, 2010). The TPACK framework (Koehler & Mishira, 2005) identifies how the combination of three different teacher knowledge domains—technology, pedagogy, content—interact in practice (See Figure 1).

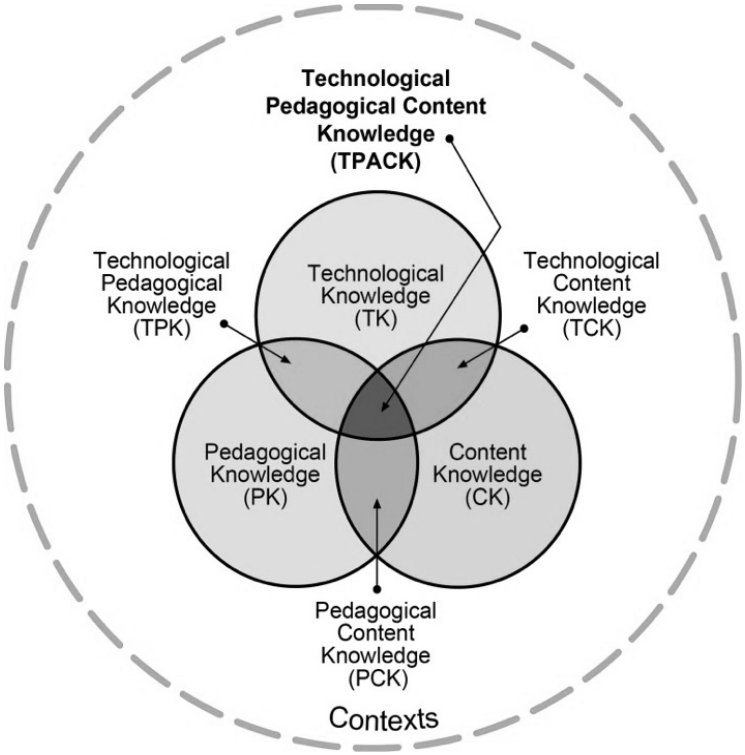

Figure 1. TPACK Framework (tpack.org)

Based on Shulman's (1986) notion of pedagogical content knowledge (PCK) in classroom practice, the framework illustrates what teachers know about their teaching content, how they decide to teach the content, and what tools and resources they use to implement their lesson plans. TK (Technology Knowledge) is one of the four different types of teacher knowledge, along with technology pedagogical knowledge (TPK), technology content knowledge (TCK), and TPACK. TK is the knowledge and use of technology that includes hardware, software, digital media and resources. TPK explains that knowledge of how technology can support teaching and change the results of learning

through particular technologies. TCK shows the knowledge of integrating technologies into content-based teaching and how the application of technology supports the subject matter rather than separately. TPACK is the desired combination of teacher knowledge, defined as "the knowledge, decision-making, and design of teaching subject matter to students with content-based technology tools or representations and/or using content-specific, technology-based assessment strategies in ways that meet content-specific learning goals and address student subject-specific misconceptions or mistakes" (Roblyer & Hughes, 2019, p. 17).

Recently, digital literacy is suggested to equate TK as practical knowledge and skills of technologies (Wilson et al., 2020), which means knowledge about the "ever-evolving technology" and "open-ended interaction with technology" (p. 4). TK also includes the skills necessary to operate the technologies (Hofer & Grandgenett, 2012), which suggest that teachers' digital literacy can be considered as technological knowledge and skills for technology integration. The TPACK framework is well-established, but it has been challenged that it is often unclear what kind of technology, processes of knowledge, or skills the TK comprises despite the impact of TK on TPACK (Chai & Koh, 2013; Seufert et a., 2019). For example, in a structural equation model of Chai and Koh (2013), TK were perceived to have positive effects on TPACK, TCK, and TPK, suggesting that even experienced teachers with pedagogical expertise may not transfer their expertise in teaching when they lack technological proficiency. The TK domain affects the total TPACK score (Jang, 2010; Taimalu & Luik, 2019). Moreover, TK was more significantly

correlated with the technology acceptance than PK and CK (Yang et al., 2021). Furthermore, it is still unclear how TK is developed in relation to what preservice teachers' experiences as part of content and pedagogical knowledge (Listiawan et al., 2018).

In consideration of the nature of TPACK, which interconnects the whole knowledge domains in contexts, studies started to focus on the combinations and dynamics among digital literacy and TPACK. In fact, digital literacy is closely related to preservice teachers' TPACK (Altun, 2019) and has a positive effect on the ability of preservice teachers TPACK to create learning tools (Fazilla et al., 2022).

Less-explored is how digital literacy as a form of teacher knowledge and skills emerges during the content, pedagogical knowledge-related activities and practices of preservice teaching (Tyarakanita, 2020). Supporting the development of TK as well as digital literacy should be included as essential knowledge and skills to facilitate understanding of technology use in learning and teaching. Also, preparation should focus on the affordances of technology which emphasize strategic approaches based on how to use a certain technological tool, why such decisions support student learning, and under what conditions the use of technology can be useful for both students and teachers. Furthermore, in a specific study, it was found that TK only significantly varied depending on experience (Saltan & Arslan, 2017), which implies the importance of providing experiences of technology use through activities and practices in teacher education. The following section reviews literature that investigated more specific learning activities and

teaching practices with technology in educator preparation programs to support preservice teacher learning for digital literacy conceptions.

Preservice Teacher Learning for Conceptualizing Digital Literacy

All new U.S. teachers are expected to integrate technology in classroom teaching (USDOE, 2022); therefore, educator preparation programs incorporate teacher technology learning experiences. Several studies have explored learning activities or teaching practices that are designed and implemented for preservice teachers as a part of coursework in teacher education. For example, Wilson et al. (2020) identified core design features in teacher education courses that support preservice teachers' technology integration knowledge development. The eight design features include: (a) practice lesson planning, (b) hands-on learning, (c) rehearsal/field experience, (d) mentoring/coaching, (e) observation, (f) goal setting, (g) reflection/self-evaluation, (h) work sample analysis.

Similarly, Seufert et al.'s (2021) review of teachers' technology related knowledge, skills, and attitudes provided six themes for preparing preservice teachers to include technology in their classroom practices: (a) role models, (b) reflection, (c) instructional design, (d) collaboration, (e) authentic experience, and (f) feedback. These two studies suggested that supporting preservice teacher learning tends to be embedded in teacher education coursework through a range of learning activities and teaching practices. Guided by themes taken from Wilson et al. and Seufert et al, this section reviews some of the existing literature with a focus on what specific technology-related learning experiences

have offered for preservice teachers' digital literacy conceptions and how such experiences are embedded in teacher education courses.

Role Models

Crucial to supporting preservice teachers' digital literacy conceptions is providing role models for preservice teachers to observe and apply the specificity of technology use for the subject matter. Kay (2006) noted the role of modeling in providing concrete and detailed examples of technology use that potentially support the development of a body of teacher knowledge for dealing with complex learning situations in actual technology-supported teaching practices. Hughes et al. (2016) focused on the explicit connections between technologies, pedagogical rationales, and the faculty's content expertise in particular contexts, and conceptualized this coordinated approach to technology preparation as a form of "faculty technological modeling" (p. 199).

In their study, Zipke et al. (2019) found that after preservice teachers were introduced to examples of technology use aligned with specific pedagogical strategies and goals in the teaching content during their course, nearly two-thirds of the guided ways of using technology were included in their course assignments and practices. Moore and Bell (2019) contributed additional categories on instructor modeling including: implicit, explicit, explicit with reflection, and explicit with connection to theory. By identifying "types" of modeling, Moore and Bell found a significant gap in current empirical knowledge in regard to the effectiveness and importance of instructor modeling,

particularly on the degree to which such modeling results in effective changes once preservice teachers begin their practice.

Reflection

Preservice teachers also learn about technology integration by engaging in reflective thinking. Bruce and Chiu (2015) explored English language arts preservice teachers' reflections on their learning experience with creating a short video and practicing multimodal literacies. Along with the video production activity, reflection on the use of technology facilitated their learning. The guided reflection focused on what preservice teachers practiced during the process of video production, what they perceived as curricular value, and how they felt for both enjoyment and frustration with the process.

Boutelier et al. (2021) described having an opportunity to reflect on how teaching plans are implemented in a class provides a new way to think about instructional decisions as well as a more student-centered approach to shape technology use. The reflections on lessons included providing detailed feedback in a variety of modes for students who needed deeper guidance to actually read and hear the constructive feedback. The self-reflective tool supported preservice teachers to critically examine their teaching and its influence.

Instructional Design

Preservice teachers learn by making connections between teaching knowledge, practices, and instructional decisions through practicing lesson planning. For example,

preservice teachers in Abbitt and Davis (2021) were introduced to virtual reality as potential instructional technology in a one-semester (3 credit hour) course focusing on technology integration in K–12 education. As a part of course assignments, preservice teachers created learning activities that would integrate this virtual reality into their teaching and designed lesson plans. Preservice teachers' lesson plans were then analyzed to understand the nature of technology integration.

Similarly, in Arya et al. (2020), language arts preservice teachers created lesson plans that integrated technology into their teaching subject and were found useful to practice their instructional decisions for searching and selecting the most appropriate digital tools to meet the instructional goals, while still considering the content-specific area. in a classroom setting. In Lee and Lee (2014), lesson planning practice as part of course assignments turned out to be the most significant activity that increased preservice teachers' self-efficacy beliefs in technology use. The study highlighted the role of instructional planning in applying teaching knowledge and skills to the subject as well as the target students' needs in learning.

Collaboration

Preservice teachers have opportunities to work together with fellow students, supporting each other, and sharing experiences. Mitchell et al. (2019) found that collaborative blogging between two universities expanded professional learning opportunities, which eventually allowed them to share applications and artifacts used or

observed in their field placements. Phillips (2016) described the dynamics and influences among peers, near-peers, and mentors within a professionally bounded group. For example, one of the participants, Anna revealed that her imagined future trajectory as "a centripetally participating classroom teacher" (Phillips, 2016, p. 128). Her desire to strengthen technology use was supported through her peer relationships with Jake by sharing knowledge in practice and experiences with technology, which helped them to align with their community's values and goals in using technology.

Feedback

Preservice teachers receive feedback about their use of technology. In Açikgül (2020), preservice mathematics teachers designed game activities using GeoGebra software, which is an interactive geometry, algebra, statistics and calculus application. Microteaching practice supported the preservice teachers as they planned lessons, presented these lessons to their peers, and evaluated their lessons. The result of this analysis found a statistically meaningful difference for the overall survey as well as for all dimensions of it.

Ledger & Fischetti (2020) combined microteaching and simulation to create a controlled learning environment that provided less complexity and variance than preservice teachers would experience in real-classroom settings. Drawing on research in situated learning and reflective practice, they showed that the combination of offering more choices

and opportunities for preservice teachers to experience learning with technology increased self-efficacy among preservice teachers.

Authentic Experience

Field experience provides preservice teachers with an opportunity to plan, apply, and assess technology use in a real classroom context with actual K–12 students. Schmid and Hegelheimer's (2014) longitudinal case study examined the field experiences of English foreign language preservice teachers across a span of years. Schmid and Hegelheimer found that the teachers valued the teaching practice for designing lessons with technology and later applied their teaching plans into classrooms.

Lux and Lux (2015) also found that preservice teachers felt more confident in using technology after having teaching practice in an actual classroom setting with students. The preservice teachers valued the rehearsal of their teaching practice before they visited the classroom. Lux and Lux noted that preservice teachers mostly responded that they felt confident in delivering their instruction to the students.

Nelson and Hawk (2020) also showed the importance of quality field experiences that include examples of technology use that extend a basic, passive technology use into a "active, constructive, intentional, authentic, and cooperative" (p. 3) means of learning. The study analyzed a total of 211 preservice teacher survey responses, which focused on their observation and practice of technology use during field experiences. The results revealed

that frequently observing quality technology use during the field experiences affected preservice teachers' beliefs and intentions to use technology in a positive way.

In summary, the research suggests that preservice teachers' digital literacy is shaped by faculty modeling and student activities in coursework, which include reflection, instructional design practice, collaboration with peers, and practical technology use in their field experiences across an educator preparation program. The key to supporting preservice teachers' digital literacy is that their conception of their own digital literacy as a future educator is mediated by an individual perspective of technology use that is situated in a particular educational context, in which technology use has been often modeled, observed, guided, and interpreted across their learning experiences. Such dynamics of preservice teacher learning call attention to a more integrated approach to better understand the linkages between the ways teacher learning experiences are provided and the ways that they become prepared with professional knowledge and skills for technology integration in their future classrooms.

Chapter 3: Discussion

Findings from the review of literature on teachers' digital literacy and preservice teacher learning to conceptualize their own digital literacy during teacher preparation revealed the two themes.

Context Shapes Teachers' Digital Literacy Learning

One of the themes arising from the research on preservice teachers' digital literacy conceptions is the learning experiences of preservice teachers in digital literacy that are often designed within certain learning activities and teaching practices. The underlying idea is that preservice teacher learning is not a passive process of absorbing information but more about interpreting new ideas based on what they experience where the learning occurs (Putnam & Borko, 2000).

Previous studies have pointed out that the quantity and quality of technology experiences play an important role in shaping new teachers' technology use (Mouza et al., 2014). Tatto (2021) noted that university-based educator preparation programs are uniquely suited to provide preservice teachers with the body of knowledge that is essential to develop their professional expertise in teaching. What preservice teachers observed from their faculty and clinical educators during their coursework served as a source of reference for making pedagogical decisions in technology use during their student teaching (Polly et al., 2020). Also, witnessing how mentor teachers or inservice cooperating teachers use

technology in their field placement classroom had a significant influence on preservice teachers' intentions to use technology (Nelson, 2019).

It suggests that teacher educators need to focus on how to provide more intentional and reflective learning opportunities for preservice teachers, and promote transferrable knowledge for their future teaching contexts based on such experiences from coursework. Mouza (2017) also argued for research interests and strategies beyond standalone educational technology coursework, explaining the interconnections among content, pedagogy, and technology to construct a body of teacher knowledge that best supports it in ways that optimally engage students of diverse needs and participation in learning. Tondeur et al. (2019) also noted that teacher educators are gatekeepers and role models for next generation teachers' technology integration, and they suggested that preservice teachers need opportunities to reflect on the role of technology in education, authentic technology experiences, and continuous feedback. Kim and Higgs (2023) added that including a selection of digital tools in the particular learning context under pedagogical, professional guidance has the potential to shift preservice teachers' pre-existing conceptions.

Embedded Digital Literacy Instruction

Another theme emerging from research is the need for a program-wide digital literacy in teacher education curriculum. De León et al. (2021) argue that supporting preservice teachers' digital literacy requires a purposeful integration of technology that is aligned with an intentional pedagogy application throughout teacher education courses,

curricular sequences and larger program objectives. For example, they developed an assessment tool based on the ISTE Educator Standards to diagnostic preservice teachers' digital literacy at the beginning of their teacher education program. Another study, Hurlbut et al. (2020) reported ways of formative assessment also based on the ISTE Educator Standards to gauge preservice teachers' digital literacy, and then employed a digital portfolio as a tool to track their candidates' learning progress across the program.

A growing body of research on teacher preparation also has valued the creation of technology-integrated courses in disciplinary content areas rather than providing a stand-alone technology course (Admiraal et al., 2017; Trainin et al., 2018). Although stand-alone courses have traditionally been a part of many educator preparation programs (Gronseth et al., 2010), the stand-alone courses tend to be less effective in supporting preservice teachers' skills, which enable them to connect the affordance of technology to pedagogical value and the subject matter (Karatas, 2014).

When technology use was integrated across subject-matter courses, preservice teachers reported a significantly higher competency in using technology, which suggests the benefits of providing technology-integrated activities across the curriculum (Kimm et al., 2020). Mouza et al. (2017) called on researchers and educators to further explore the integrated approach to technology use that aim to provide opportunities for preservice teachers to purposefully observe how to leverage technological tools and model technology use in an environment similar to real-world school classrooms.

These two themes suggest that teachers learn the kind of digital literacy they will need in the classroom in a specific context that is both shaped by their personal experiences and the environment or program in which they learn to teach. High-quality learning experiences, embedded in subject-matter content and modeled by more expert peers or instructors give preservice teachers the opportunity to develop the knowledge and skills they need for the classroom.

Chapter 4: Implications and Conclusion

This chapter presents implications taken from the literature regarding preservice teachers' digital literacy in educator preparation programs. Limitation and conclusion of this literature review are also included.

Implications

Three implications are taken from the literature:

1. Domain-specific: Teacher digital literacy is a specific domain within general digital literacy.
2. Learned: Teacher digital literacy that allows teachers to integrate technology is learned.
3. Context-specific: To effectively support preservice teachers' digital literacy conceptions, teacher candidates must account for not only the knowledge and skills but also the context of technology use in teaching and learning.

First, teacher digital literacy is a specific domain within general digital literacy. Based on Wilson et al. (2020) and Fazilla et al. (2022), this is a form of specific literacy that is narrower than the general digital literacy that preservice teachers have as they enter an educator preparation program. Teacher digital literacy is made up of knowledge and skills that allow teachers to shape digital media and technology to create learning opportunities (Hague & Payton, 2011), particularly what the use of technology means and how it helps in achieving goals in their work.

Second, this form of teacher digital literacy that allows teachers to integrate technology is learned. The professional capacity does not just come with practice (Lawrence, et al., 2020; Kimm et al., 2022). In the context of teacher preparation, preservice teachers—as future educators—would benefit from understandings and skills of how to integrate technologies to provide their students with learning opportunities. For that, preservice teachers need support and preparation in their teacher education program.

Third, to effectively support preservice teachers' digital literacy conceptions, teacher candidates must account for not only the knowledge and skills but also the context of technology use in teaching and learning. Teachers' digital literacy is socially-mediated and specific to the context in which it occurs (Phillips, 2016). Preservice teachers begin to conceptualize their own digital literacy with specific technology-related learning experiences, including the use of role models, reflection, instructional design, collaboration, feedback, and authentic experiences. What makes the digital literacy conceptions unique is that the teacher's knowledge development is often closely related to the contextual conditions of their learning, including what preservice teachers observe, interpret, or practice through curriculum, certain norms or rules in the program, and even certain expectations for them to use technology. The dynamics of preservice teacher learning center around and embedded in a range of learning experiences imply a need to consider a more holistic and comprehensive approach to examine preservice teacher learning for conceptualizing digital literacy.

Limitation

This report presents the review of literature that focused on how preservice teachers learn to conceptualize their own digital literacy during their teacher preparation, but it does not explore the impact of the COVID-19 pandemic (and related school closures) had on teachers' use of technology in classrooms or how the pandemic may have impacted the digital lives of preservice teachers. These are important and interesting questions.

For example, in An et al. (2021), 107 teachers from 25 states reported major challenges they faced regarding online teaching during the pandemic. Their answers included lack of student participation and engagement in technology-supported learning activities and limited interaction compared to the face-to-face classroom environment. Leech et al. (2022) also described challenges that 604 teachers had to face regarding student engagement and providing individualized additional support. Teachers also struggled to adjust their specific curriculum or teaching practice to the remote setting, finding it difficult to create the same experiences online that they could in the classroom.

Conclusion

Through engaging with a range of learning opportunities that are guided by technological modeling in coursework, practice in field experiences, and other contextual conditions, preservice teachers learn to teach with technology for their future classroom teaching. The pivotal characteristic of preservice teachers' technological preparation is that it is often closely related to the matter of what they observe, interpret, or practice across

their educator preparation program. This socially-mediated technology preparation that depends on time in particular, specific examples and cases of classroom technology use suggests that preservice teachers' conception of digital literacy can be also situated and contextualized, and is not always straightforward or consistent.

References

Açikgül, K. (2020). The effect of technological pedagogical content knowledge game activities supported micro-teaching practices on preservice mathematics teachers' self-efficacy perception levels. *Acta Didactica Napocensia, 13*(2), 157–173.

Admiraal, W., van Vugt, F., Kranenburg, F., Koster, B., Smit, B., Weijers, S., & Lockhorst, D. (2017). Preparing pre-service teachers to integrate technology into K–12 instruction: evaluation of a technology-infused approach. *Technology, Pedagogy and Education, 26*(1), 105–120.

Altun, D. (2019). Investigating pre-service early childhood education teachers' technological pedagogical content knowledge (TPACK) competencies regarding digital literacy skills and their technology attitudes and usage. *Journal of Education and Learning*, *8*(1), 249-263.

Ata, R., & Yıldırım, K. (2019). Turkish pre-service teachers' perceptions of digital citizenship in education programs. *Journal of Information Technology Education. Research*, *18*, 419.

American Library Association Digital Literacy Task Force. (2011). What is Digital Literacy?. https://alair.ala.org/bitstream/handle/11213/16260/Digilit%20definition_one%20pager_Marijke%20Visser.pdf?sequence=1&isAllowed=y

Arya, P., Christ, T., & Wu, W. (2020). Patterns of technological pedagogical and content

knowledge in preservice-teachers' literacy lesson planning. *Journal of Education and Learning, 9*(5), 1–14.

Baek, E. O., & Sung, Y. H. (2020). Pre-service teachers' perception of technology competencies based on the new ISTE technology standards. *Journal of Digital Learning in Teacher Education, 37*(1), 48–64.

Bakia, M., Means, B., Gallagher, L., Chen, E., & Jones, K. (2009). *Evaluation of the enhancing education through technology program*. U.S. Department of Education. Office of Planning, Evaluation and Policy Development. Policy and Program Studies Service. https://files.eric.ed.gov/fulltext/ED527143.pdf

Bannerman, J. K., & O'Leary, E. J. (2021). Digital natives unplugged: Challenging assumptions of preservice music educators' technological skills. *Journal of Music Teacher Education, 30*(2), 10–23.

Baran, E., & AlZoubi, D. (2023). Design thinking in teacher education: Morphing preservice teachers' mindsets and conceptualizations. *Journal of Research on Technology in Education*, 1-19.

Batane, T., & Ngwako, A. (2017). Technology use by pre-service teachers during teaching practice: Are new teachers embracing technology right away in their first teaching experience?. *Australasian Journal of Educational Technology, 33*(1), 48–61.

Bawden, D. (2008). Origins and concepts of digital literacies. In C. Lankshear & M. Knobel (Eds.), *Digital literacies: Concepts, policies & practices* (pp. 17–32).

New York: Peter Lang Publishing Inc.

Belo, N., McKenney, S., Voogt, J., & Bradley, B. (2016). Teacher knowledge for using technology to foster early literacy: A literature review. *Computers in Human Behavior*, *60*, 372-383.

Boutelier, S., Moran, C., Sullivan, S., Rybakova, K., Damico, N., & Null, S. (2021). Multimodal assessment and the new paradigm: An autoethnographic reflection on teacher education. *Journal of Technology and Teacher Education, 29*(4), 471–495.

Bower, M., DeWitt, D., & Lai, J. W. (2020). Reasons associated with preservice teachers' intention to use immersive virtual reality in education. *British Journal of Educational Technology, 51*(6), 2215–2233.

Brevik, L. M., Gudmundsdottir, G. B., Lund, A., & Strømme, T. A. (2019). Transformative agency in teacher education: Fostering professional digital competence. *Teaching and Teacher education*, *86*, 102875.

Bruce, D. L., & Chiu, M. M. (2015). Composing with new technology: Teacher reflections on learning digital video. *Journal of Teacher Education, 66*(3), 272–287.

Brush, T. (2003). Introduction to the special issue on preparing tomorrow's teachers to use technology (PT3). *Educational Technology Research and Development*, *51*(1), 39-40.

Brush, T., Glazewski, K. D., & Hew, K. F. (2008). Development of an instrument to

measure preservice teachers' technology skills, technology beliefs, and technology barriers. *Computers in the Schools, 25*(1-2), 112–125.

Calavia, M. B., Blanco, T., Casas, R., & Dieste, B. (2023). Making design thinking for education sustainable: Training preservice teachers to address practice challenges. *Thinking Skills and Creativity*, *47*, 101199.

Çetin, E. (2021). Digital storytelling in teacher education and its effect on the digital literacy of pre-service teachers. *Thinking Skills and Creativity*, *39*, 100760.

Chai, C. S., Koh, J. H. L., & Tsai, C. C. (2013). A review of technological pedagogical content knowledge. *Journal of Educational Technology & Society, 16*(2), 31-51.

Chou, C. C., & Block, L. (2019). The mismatched expectations of iPad integration between teachers and students in secondary schools. Journal of Educational Computing Research, 57(5), 1281-1302.

Cuban, L. (2001). *Oversold and underused: Computers in the classroom*. Cambridge, MA: Harvard University Press.

Cuban, L. (2013). Why so many structural changes in schools and so little reform in teaching practice?. *Journal of Educational Administration, 51*(2),109–125.

De León, L., Corbeil, R., & Corbeil, M. E. (2021). The development and validation of a teacher education digital literacy and digital pedagogy evaluation. *Journal of Research on Technology in Education*, 1-13.

Emre, D. (2019). Prospective teachers’ perceptions of barriers to technology integration

in education. *Contemporary Educational Technology, 10*(4), 381–398.

Ertmer, P. A. (1999). Addressing first-and second-order barriers to change: Strategies for technology integration. *Educational technology research and development, 47*(4), 47–61.

Ertmer, P. A., & Ottenbreit-Leftwich, A. T. (2010). Teacher technology change: How knowledge, confidence, beliefs, and culture intersect. *Journal of research on Technology in Education*, *42*(3), 255-284.

Fazilla, S., Yus, A., & Muthmainnah, M. (2022). Digital Literacy and TPACK's Impact on Preservice Elementary Teachers' Ability to Develop Science Learning Tools. *Profesi Pendidikan Dasar*, *9*(1), 71-80.

Francom, G. M. (2016). Barriers to technology use in large and small school districts. *Journal of Information Technology Education: Research, 15*, 577–591.

Fullan, M. (2011). *Change leader: Learning to do what matters most*. San Francisco: Jossey-Bass.

Gee, J. P. (2012). *Social linguistics and literacies : Ideology in discourses* (4th ed.). Routledge.

Gilster, P. (1997). *Digital literacy*. New York: NY. Wiley Computer Pub.

Goktas, Y., Yildirim, S., & Yildirim, Z. (2009). Main barriers and possible enablers of ICTs integration into pre-service teacher education programs. *Journal of Educational Technology & Society, 12*(1), 193–204.

Gonzales-Dholakia, G. (2013). *Preparing 21st Century Teachers: The Relationship of*

Technology Integration, Digital Equity, and the Preparation of New Teachers [Unpublished doctoral dissertation] The University of Texas at Austin.

Gronseth, S., Brush, T., Ottenbreit-Leftwich, A., Strycker, J., Abaci, S., Easterling, W., ... & Leusen, P. V. (2010). Equipping the next generation of teachers: Technology preparation and practice. *Journal of Digital Learning in Teacher Education*, *27*(1), 30-36.

Hague, C., & Payton, S. (2011). *Digital literacy across the curriculum: A Futurelab Handbook*. https://www.nfer.ac.uk/publications/futl06/futl06.pdf

Hofer, M., & Grandgenett, N. (2012). TPACK development in teacher education: A longitudinal study of preservice teachers in a secondary MA Ed. program. *Journal of Research on Technology in Education, 45*(1), 83-106.

Howland, J. L., Jonassen, D., & Marra, R. M. (2012). *Meaningful learning with technology* (4th ed.). Boston, MA: Allyn & Bacon.

Hramiak, A., & Boulton, H. (2013). Escalating the use of Web 2.0 Technology in Secondary Schools in the United Kingdom: Barriers and Enablers beyond Teacher Training. *Electronic Journal of E-learning*, *11*(2), 91-100.

Hughes, J. E. (2013). Descriptive indicators of future teachers' technology integration in the PK–12 classroom: Trends from a laptop-infused teacher education program. *Journal of Educational Computing Research, 48*(4), 491–516

Hughes, J. E., Liu, S., & Lim, M. (2016). Technological modeling: Faculty use of technologies in preservice teacher education from 2004 to 2012. *Contemporary*

Issues in Technology and Teacher Education, 16(2), 184–207.

Hurlbut, A. R., McMahan, S., Myers, A., Dunlap, K., & Fredrickson, R. (2020). From Start to Finish: A Programmatic Approach to Digital Literacy in Teacher Education. In *Handbook of Research on Literacy and Digital Technology Integration in Teacher Education* (pp. 1-28). IGI Global.

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

International Society for Technology in Education STE. (2023). *International Society for Technology in Education (ISTE) Edtech Policy Map*. https://www.iste.org/edtech-policy-maps

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

Kaimara, P., Fokides, E., Oikonomou, A., & Deliyannis, I. (2021). Potential barriers to the implementation of digital game-based learning in the classroom: Pre-service teachers' views. *Technology, Knowledge and Learning*, *26*(4), 825-844.

Karatas, I. (2014). Changing pre-service mathematics teachers' beliefs about using computers for teaching and learning mathematics: The effect of three different models. *European Journal of Teacher Education, 37*, 390–405.

Kay, R. H. (2006). Evaluating strategies used to incorporate technology into preservice education: A review of the literature. *Journal of research on technology in education*, *38*(4), 383-408.

Kelly, D. P. (2015). Overcoming barriers to classroom technology integration. *Educational Technology, 55*(2), 40–43.

Kim, G. M., & Higgs, J. (2023). Exploring equity issues with technology in secondary literacy education. *Technology, Pedagogy and Education, 32*(1), 1–16.

Kimm, C. H., Kim, J., Baek, E. O., & Chen, P. (2020). Pre-service teachers' confidence in their ISTE technology-competency. *Journal of Digital Learning in Teacher Education, 36*(2), 96–110.

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), 176-198.

Kist, W., & Pytash, K. E. (2015). " I Love to Flip the Pages": Preservice Teachers and New Literacies within a Field Experience, *English Education, 47*(2), 131–167.

Koehler, M. J., & Mishra, P. (2005). What happens when teachers design educational technology? The development of technological pedagogical content knowledge. J*ournal of educational computing research, 32*(2), 131–152.

Kuo, Y. C., Kuo, Y. T., & Abi-El-Mona, I. (2022). Mobile learning: pre-service teachers' perceptions of integrating iPads into future teaching. *Education and Information Technologies*, 1-22.

Lankshear, C., & Knobel, M. (Eds.). (2008). *Digital literacies: Concepts, policies and practices*. Peter Lang.

Lawrence, G., Ahmed, F., Cole, C., & Johnston, K. P. (2020). Not more technology but more effective technology: Examining the state of technology integration in EAP programmes. *RELC Journal*, *51*(1), 101-116.

Ledger, S., & Fischetti, J. (2020). Micro-teaching 2.0: Technology as the classroom. *Australasian Journal of Educational Technology, 36*(1), 37–54.

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

Lei, J. & Zhao, Y. (2007). Technology uses and student achievement: A longitudinal study. *Computers & Education, 49* (2), 284-296.

Lemon, N., & Garvis, S. (2016). Pre-service teacher self-efficacy in digital technology. *Teachers and Teaching, 22*(3), 387–408.

Leu, D. J., Forzani, E., Burlingame, C., Kulikowich, J., Sedransk, N., Coiro, J., & Kennedy, C. (2013). The new literacies of online research and comprehension: Assessing and preparing students for the 21st century with Common Core State Standards. *Quality reading instruction in the age of Common Core Standards*, 219–236.

Listiawan, T., As'ari, A. R., & Muksar, M. (2018, November). Mathematics teachers

technological content knowledge (TCK) in using dynamic geometry software. In *Journal of Physics:Conference Series, 1114(*1). IOP Publishing.

Lux, N., & Lux, C. (2015). The influence of technology-rich early childhood field experiences on preservice teachers. *Journal of Technology and Teacher Education, 23*(2), 213–240.

Margolin, J., Pan, J., & Yang, R. (2019). Technology Use in Instruction and Teacher Perceptions of School Support for Technology Use in Iowa High Schools. REL 2019-004. *Regional Educational Laboratory Midwest*.

Martin, A., & Grudziecki, J. (2006). DigEuLit: Concepts and tools for digital literacy development. *Innovation in teaching and learning in information and computer sciences*, *5*(4), 249-267.

Mims, C., Polly, D., Shepherd, C., & Inan, F. (2006). Examining PT3 projects designed to improve preservice education. *TechTrends*, *50*(3), 16-24.

Mitchell, F. L., & Appleget, C. (2019). Preservice teachers' blogging: collaboration across universities for meaningful technology integration. *Teaching Education* (Columbia, S.C.), 30(4), 356–372.

Moore, E. J., & Bell, S. M. (2019). Is instructor (faculty) modeling an effective practice for teacher education? Insights and supports for new research. *Action in Teacher Education*, *41*(4), 325-343.

Mouza, C. (2017). Editorial: Beyond Standalone Educational Technology Coursework:

K-16 Teacher Preparation Strategies. *Contemporary Issues in Technology and Teacher Education, 17*(3), 291–294.

Mouza, C., Karchmer-Klein, R., Nandakumar, R., Ozden, S. Y., & Hu, L. (2014). Investigating the impact of an integrated approach to the development of preservice teachers' technological pedagogical content knowledge (TPACK). *Computers & Education, 71*, 206–221.

Nelson, M. J., Voithofer, R., & Cheng, S. L. (2019). Mediating factors that influence the t technology integration practices of teacher educators. *Computers & Education*, *128*, 330-344.

Nelson, M. J., & Hawk, N. A. (2020). The impact of field experiences on prospective preservice teachers' technology integration beliefs and intentions. *Teaching and Teacher Education, 89*, 103006.

New London Group. (1996). A pedagogy of multiliteracies: Designing social futures. *Harvard Educational Review, 66*. 60-92.

Organisation for Economic Co-operation and Development (2020). *Global Teaching InSights: A Video Study of Teaching. Paris. O*ECD Publishing. https://doi.org/10.1787/20d6f36b-en.

Peled. (2021). Pre-service teacher's self-perception of digital literacy: The case of Israel. *Education and Information Technologies, 26*(3), 2879–2896. https://doi.org/10.1007/s10639-020-10387-x

Phelps, A., Colburn, J., Hodges, M., Knipe, R., Doherty, B., & Keating, X. D. (2021). A

qualitative exploration of technology use among preservice physical education teachers in a secondary methods course. *Teaching and Teacher Education, 105*, 103400.

Phillips, M. (2016). Re-Contextualising TPACK: exploring teachers'(non-) use of digital technologies. *Technology, Pedagogy and Education, 25*(5), 555–571.

Polly, D. (2014). Deepening pre-service teachers' knowledge of technology, pedagogy, and content (TPACK) in an elementary school mathematics methods course. *Journal of Computers in Mathematics and Science Teaching*, *33*(2), 233-250.

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.

Polly, D., Mims, C., Shepherd, C., & Inan, F. (2010). Evidence of impact: Transforming teacher education with preparing tomorrow's teachers to teach with technology (PT3) grants. *Teaching and Teacher Education, 26*(4), 863–870.

Pringle, R. M., Dawson, K., & Ritzhaupt, A. D. (2015). Integrating science and technology: Using technological pedagogical content knowledge as a framework to study the practices of science teachers. *Journal of Science Education and Technology, 24*, 648–662.

Putnam, R., & Borko, H. (2000). What do views of knowledge and thinking have to say about research on teacher learning? *Educational Researcher, 21*(1), 4–15.

Roblyer, M. D., & Hughes, J. E. (2019). *Integrating educational technology into teaching: Transforming learning across disciplines*. Pearson Education, Incorporated.

Saltan, F., & Arslan, K. (2017). A comparison of in-service and pre-service teachers' technological pedagogical content knowledge self-confidence. *Cogent Education*, *4*(1), 1311501

Sánchez-Cruzado, C., Santiago Campión, R., & Sánchez-Compaña, M. T. (2021). Teacher digital literacy: The indisputable challenge after COVID-19. *Sustainability*, *13*(4), 1858.

Schmid, E. C., & Hegelheimer, V. (2014). Collaborative research projects in the technology-enhanced language classroom: Pre-service and in-service teachers exchange knowledge about technology. *ReCALL, 26*(3), 315–332.

Scribner, S. & Cole, M. (1981). *The Psychology of Literacy*. Cambridge MA: Harvard University Press.

Seufert, S., Guggemos, J., & Sailer, M. (2021). Technology-related knowledge, skills, and attitudes of pre-and in-service teachers: The current situation and emerging trends. *Computers in Human Behavior, 115*, 106552.

https://capitol.texas.gov/BillLookup/Text.aspx?LegSess=85R&Bill=SB1839

Selwyn, N., Hillman, T., Bergviken Rensfeldt, A., & Perrotta, C. (2023). Digital technologies and the automation of education: key questions and concerns. *Postdigital Science and Education*, *5*. https://doi.org/10.1007/s42438-021-00263-3

Shively, K., & Palilonis, J. (2018). Curriculum development: Preservice teachers' perceptions of design thinking for understanding digital literacy as a curricular framework. *Journal of Education, 198*(3), 202–214.

Shulman, L.S. (1986). Those who understand: Knowledge growth in teaching. *Educational researcher, 15*(2), 4–14.

Street, B. (2003). What's "new" in New Literacy Studies? Critical approaches to literacy in theory and practice. *Current issues in comparative education, 5*(2), 77–91.

Strudler, N., Archambault, L., Bendixen, L., & Anderson, D., & Weiss, R. (2003). Project THREAD: Technology helping restructure educational access and delivery. *Educational Technology Research and Development*, *51*(1), 41-56.

Taimalu, M., & Luik, P. (2019). The impact of beliefs and knowledge on the integration of technology among teacher educators: A path analysis. *Teaching and teacher Education*, *79*, 101-110.

Tatto, M. T., & Coupland, D. B. (2003). Teacher education and teachers' beliefs. *Teacher beliefs and classroom performance: The impact of teacher education*, *6*, 123-182.

Texas Legislature Online (2023). *Relating to the preparation, certification, and classification of and professional development for public school educators*, S. bill/SB 1839, 85(R). (2017).

Tissenbaum, M., & Slotta, J. D. (2019). Developing a smart classroom infrastructure to support real-time student collaboration and inquiry: A 4–year design study. *Instructional Science, 47*(4), 423–462.

Tondeur, J., Pareja Roblin, N., van Braak, J., Voogt, J., & Prestridge, S. (2016). Preparing beginning teachers for technology integration in education: Ready for take-off? Technology, *Pedagogy and Education, 26*, 157–177. https://doi.org/10.1080/1475939X.2016.1193556

Tondeur, J., Scherer, R., Baran, E., Siddiq, F., Valtonen, T., & Sointu, E. (2019). Teacher educators as gatekeepers: Preparing the next generation of teachers for technology integration in education. *British Journal of Educational Technology*, *50*(3), 1189-1209.

Trainin, G., Friedrich, L., & Deng, Q. (2018). The impact of a teacher education program redesign on technology integration in elementary preservice teachers. *Contemporary Issues in Technology and Teacher Education, 18*(4), 692–721.

Tsai, C. C., & Chai, C. S. (2012). The" third"-order barrier for technology-integration instruction: Implications for teacher education. *Australasian Journal of Educational Technology*, *28*(6).

Tyarakanita, A. (2020). A case study of pre-service teachers' enabling TPACK knowledge: Lesson design projects. *ELS Journal on Interdisciplinary Studies in Humanities*, *3*(2), 158-169.

U.S. Department of Education Office of Educational Technology. (2006, September 20). Preparing Tomorrow's Teachers to Use Technology Program (PT3). https://www2.ed.gov/programs/teachtech/performance.html

U.S. Department of Education Office of Educational Technology (2022). Launching a

Digital Literacy Accelerator.
https://tech.ed.gov/launching-a-digital-literacy-accelerator/

Valtonen, T., Sointu, E., Kukkonen, J., Mäkitalo, K., Hoang, N., Häkkinen, P., ... & Tondeur, J. (2019). Examining pre-service teachers' Technological Pedagogical Content Knowledge as evolving knowledge domains: A longitudinal approach. *Journal of Computer Assisted Learning, 35*(4), 491-502.

Voet, M., & De Wever, B. (2017). Towards a differentiated and domain-specific view of educational technology: An exploratory study of history teachers' technology use. *British Journal of Educational Technology, 48*, 1402–1413.

Wilson, M. L., Ritzhaupt, A. D., & Cheng, L. (2020). The impact of teacher education courses for technology integration on pre-service teacher knowledge: A meta-analysis study. *Computers & Education, 156*, 103941.

Yang, J., Wang, Q., Wang, J., Huang, M., & Ma, Y. (2021). A study of K-12 teachers' TPACK on the technology acceptance of E-schoolbag. *Interactive Learning, Environments*, *29*(7), 1062-1075.

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.