

Hassan, R., Fu, Y., & Ware, T. F. (2025). Practices, attributes, and contextual factors shaping teacher educators' technology leadership: A systematic literature review. *Contemporary Issues in Technology and Teacher Education*, 25(4), 710-735.

Practices, Attributes, and Contextual Factors Shaping Teacher Educators' Technology Leadership: A Systematic Literature Review

[Ragia Hassan](#)

Indiana University of Pennsylvania

[Yao Fu](#)

University of Wisconsin-Whitewater

[Tammy Fry Ware](#)

MidAmerica Nazarene University

Although the literature underscores the importance of teacher educators' roles in technology leadership, there remains a need to clearly define this concept within teacher education and to understand the attributes and practices that enable teacher educators to act as technology leaders, as well as the factors influencing their leadership in technology integration. To address this gap, the authors conducted a systematic review of the literature on technology leadership in teacher education. Guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), 29 studies were identified, published between 2010 and July 2024 from five databases. Through thematic analysis, a functional definition of technology leadership in teacher education was proposed and the essential attributes and practices that underpin teacher educators' leadership in technology integration were unveiled. The study revealed a range of contextual factors that could shape technology leadership in teacher education programs, including institutional influences, programmatic challenges, mentor teacher readiness, and national policy and cultural norms. These findings provide important implications for future research on teacher educators as technology leaders.

The evolving role of teacher educators in higher education as technology leaders highlights their influence on shaping educational paradigms through integrating digital tools and pedagogies. Teacher educators are defined here as higher education instructors who teach and work with undergraduate and graduate students enrolled in teacher preparation programs.

As the landscape of higher education undergoes a significant transformation, driven by rapid technological advancements, teacher educators are uniquely positioned to foster a culture of innovation and digital literacy (Gruszczynska et al., 2013). Technology leadership influences both curriculum development and instructional design in teacher education programs across varied institutional settings (Roth & Price, 2016). The literature documents that leadership roles contribute to shifts in curriculum and instruction.— whether assumed by teacher educators driving e-portfolio integration, by faculty members improving their technological pedagogical content knowledge (also known as technology, pedagogy, and content knowledge [TPACK]), or through institutional initiatives such as mobile technology curricula and diagnostic leadership tools.

Studies show teacher educators can act as technology leaders, influencing curriculum changes and supporting faculty members (Herring et al., 2014; Lundeberg et al., 2004), while others describe how TPACK frameworks guide program redesign and blended instructional models (Clausen et al., 2019; Jaipal-Jamani et al., 2018; Nelson et al., 2019). Jaipal-Jamani et al. suggested that taking on technology leadership roles significantly improves faculty members' TPACK and skills. Other studies suggest that institutional commitment, clear leadership vision, and robust professional development emerge as factors associated with these improvements (Burke & Foulger, 2014; Nelson et al., 2019), as seen by enhanced alignment with the International Society for Technology in Education (ISTE) standards (2017) and a transition from standalone information and communication technology (ICT) courses to embedded technology approaches (Tondeur et al., 2013).

This systematic review synthesized current research to explore how educators are not only adapting to technological changes but spearheading efforts to embed technology leadership within teacher education programs, thereby preparing future educators to effectively utilize technology-enhanced learning environments. The studies we reviewed in this paper reported various factors, challenges, outcomes, and practices related to technology integration in teacher education.

Additionally, this review explored the concept of technology leadership in teacher education. It examined how educators used their expertise to enhance technological competencies in teacher preparation. The study aimed to identify key leadership attributes and mechanisms for transferring expertise, offering strategies to integrate technology leadership into teacher education programs effectively. Currently, there is a gap in the knowledge of technology leadership roles played by teacher educators. Specifically, there is a need to define the concept of technology leadership in teacher education and understand the attributes and mechanisms for transferring expertise, as well as strategies to integrate technology leadership into teacher education programs. Given the

limitations in the literature, our systematic review aimed to close the gap by addressing the following four research questions:

1. How is teacher educators' technology leadership defined in teacher education contexts?
2. What are the best practices of teacher educators in integrating technologies to enhance teacher preparation?
3. What are some attributes of teacher educators that empower them to be technology leaders in teacher education?
4. What are contextual factors that might influence teacher educators' technology integration in teacher education programs?

Literature Review

Teacher Educators' Technology Leadership

This literature review examines the role of higher education teacher educators in teacher preparatory programs as leaders in technology who can directly influence the development of teacher candidates as technology leaders. The importance of this technology-leading teacher educator role is consistently underscored throughout the literature (Howell et al., 2014). Research suggests that a stand-alone course on technology in teacher preparation programs is not enough to provide varied ways to present technology to teacher candidates to develop their abilities as technology leaders (Nelson et al., 2019). Instead, active learning opportunities should be embedded in teacher education programs through all proactive coursework and practice to ensure this concept of leadership is transferred effectively (Landon-Hays et al., 2020).

Ultimately, teacher educators serve as pivotal agents in modeling and enacting technology leadership within teacher preparation programs. By intentionally integrating digital tools across coursework, demonstrating innovative pedagogical practices, and fostering reflective engagement with technology, they not only shape candidates' instructional competencies but also cultivate their leadership capacities. In this way, teacher educators function as both role models and catalysts, ensuring that the next generation of teachers enters the profession prepared to lead technology integration in their own classrooms and school communities.

Key Attributes of Technology Leaders

Higher education professionals have the task of preparing teacher candidates as educational leaders in the integration of technology. The attributes necessary for these professionals are critical for influencing and modeling for these future teacher leaders. The current literature explores these attributes and how these professionals can transfer their knowledge and skills to prepare candidates as future technology leaders. Educational technology leaders are not only those who practice technology but also those who must be catalysts for the progression of effective technology understanding and integration.

Barger (2017) contended that technology integration should support sound pedagogical practices and should not dictate them; therefore, learning outcomes remain at the forefront of practice. Cortellazzo et al. (2019) established a broad definition of leadership as a guide for a group of people or an organization that empowers their transformational processes. In this way, higher education professionals who work with teacher candidates design preparatory courses and experiences to instill this concept of leadership in future teachers.

Transfer of Knowledge and Skills

Basantes-Andrade et al. (2022) discussed Prendes and Guitierrez's (2013) suggestion of a shift for those working with teacher candidates from simply using technology to promoting pedagogical innovation and practice and also stressed the importance of continuous professional development in the area of technology integration. This professional learning must include the preparation, as well, of those higher education professionals who are transferring their technological knowledge to the teacher candidates.

For this transfer to occur, instructors in higher education teacher education programs must, themselves, be prepared in digital pedagogies (Basantes-Andrade et al., 2022). Many preservice teachers are not adequately prepared to practice effective pedagogical uses of technology, most likely due to the absence of present and ongoing professional development once in the classroom. Many times, integration is blocked due to a lack of support, a lack of resources, and a lack of knowledge.

The literature increasingly recognizes teacher educators' responsibilities as technology leaders who are expected to demonstrate professional attributes and transfer their technological knowledge and skills to strengthen teacher preparation. However, there remains limited conceptual clarity regarding what technology leadership entails within teacher education contexts. In particular, little is known about the specific attributes that enable teacher educators to serve as technology leaders, the practices they employ in leading technology integration, and the contextual factors that are beyond their control but may influence their leadership. These gaps underscore the need to develop a more in-depth understanding of teacher educators' technology leadership.

Methods

To fill the aforementioned gaps, we conducted a systematic review to investigate the four research questions of our study, including the definition of technology leadership for teacher educators, their best practices for technology integration in teacher preparation, the key attributes that empower them, and the contextual factors that influence their technology integration efforts. Following the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines (Page et al., 2021), we collected peer-reviewed journal articles published between 2010 and July 2024 from five high-quality databases. The following section describes our search strategy, screening process, and criteria, along with methods of data analysis.

Search Strategy

To identify appropriate studies for our review, we used two search strings: “technology leadership” AND “teacher education” to conduct searches in Eric, Web of Science (WoS), Scopus, Google Scholar, and PsycINFO. These five databases were selected because they provide a wide coverage of peer-reviewed journal articles that are high quality and suited our needs.

We applied the PRISMA guidelines (Page et al., 2021) and inclusion and exclusion criteria (see Table 1) to inform our research selection and screening process. Specifically, we initially identified a total of 234 studies across five databases. After removing duplicates and screening abstracts and full texts, we retained 29 articles that satisfied our criteria in this systematic review. Figure 1 provides details of the study identification procedure.

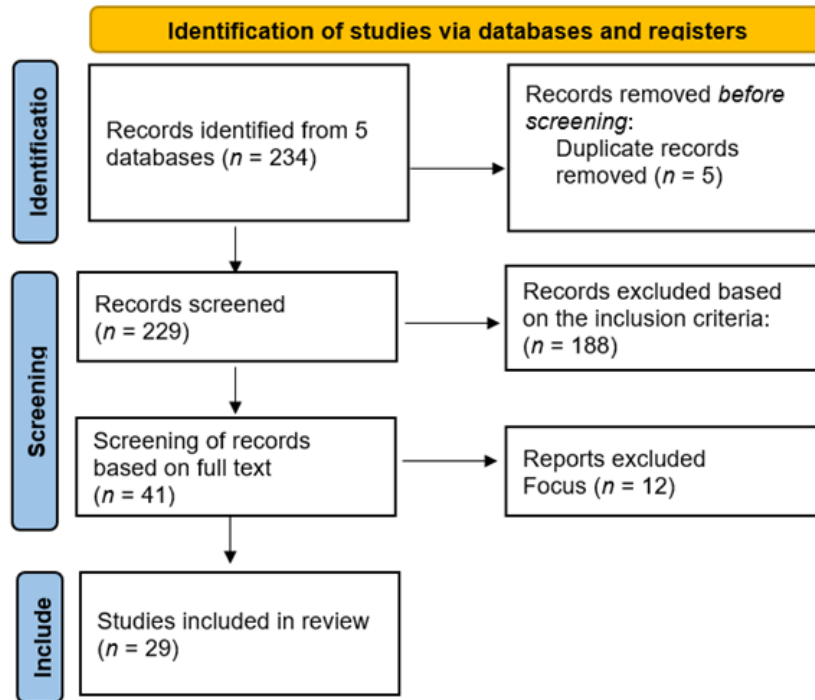
Table 1
Inclusion and Exclusion Criteria

Category	Inclusion	Exclusion
Publication Type	Peer-reviewed journal articles	Dissertation, book chapters, books
Language	Full text written in English	Full text written in other languages
Time span	2010-2024 (July)	Published before 2010 and after July 2024
Participants	Teacher educators and/or preservice teachers and in-service teachers associated with teacher education programs	Other stakeholders
Target setting	Teacher education programs	K-12 schools unrelated to student teaching settings & other higher education programs
Focus	Technology leadership and its development in teacher education programs	Other topics not relevant to technology leadership and its development in teacher education programs
Access	Have access to full-text	No access to full-text

Data Analysis

We adopted thematic analysis (Boyatzis, 1998) and open coding to analyze the 29 included studies to explore key underlying themes aligned with our four research questions. To improve the reliability of our analysis, we carefully read the included studies and independently coded them. Then, we held several meetings to compare our codes and reach a consensus on the key categories of our codes through our meeting discussions.

Figure 1
PRISMA Flowchart



Apart from conducting thematic analysis, we examined the metadata of the included studies to provide information about the publication year, author collaboration, and the first author's country/region. In terms of publication years, as shown in Figure 2, we found that 2020, 2021, and 2024 were the three most productive years, with five studies published in each, followed by 2019 when four studies were published. By contrast, there was no relevant article published in 2022 included in our review.

We also found that only four included articles (i.e., 13.79% of the total articles) were written by a single author, while the rest were written through the collaboration of at least two authors. Among those author collaborations, 68.97% were domestic coauthored and 17.24% were international coauthored (see Figure 3). Regarding the country/region of the first author, the U.S. contributed 15 articles, which is more than half of the total studies included in this review. The U.K., Norway, and Australia ranked as the second-most productive countries, with each contributing two articles to this review.

Figure 2
Publication Year of the Included Studies

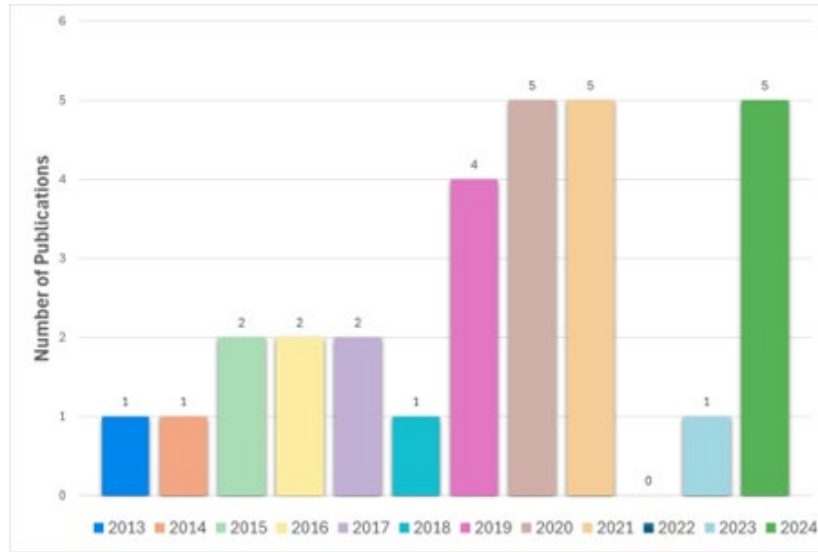
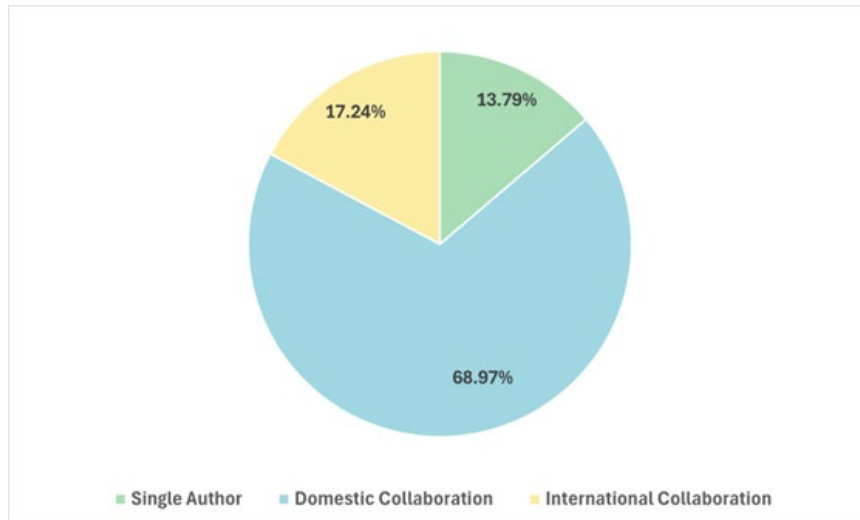


Figure 3
Author Collaboration

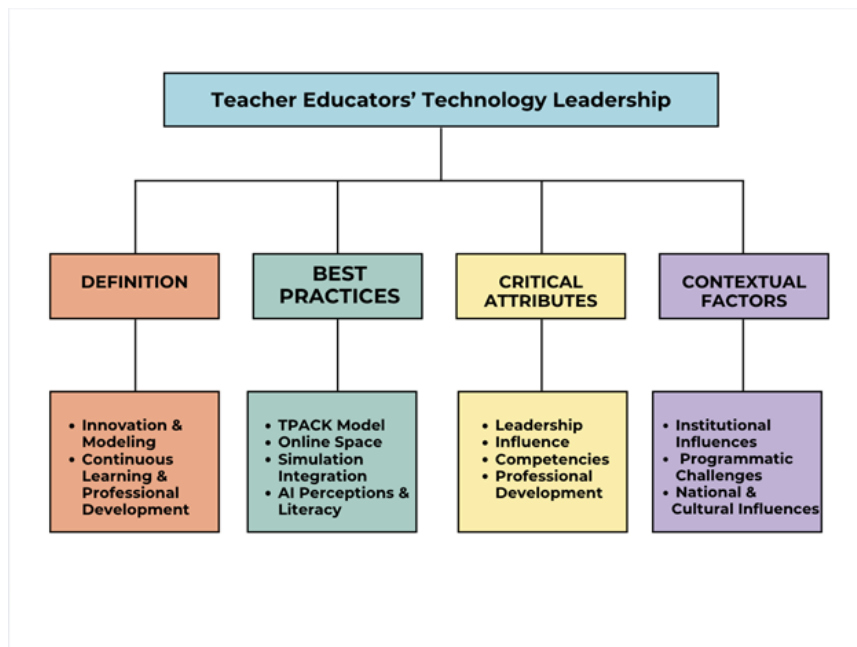


Results

Our thematic analysis uncovered major themes related to our research questions, encompassing the definition of teacher educators' technology leadership, teacher educators' best technological practices in teacher preparation, key attributes of these technology leaders, and influencing contextual factors that might shape teacher educators' technology integration into teacher education programs. Figure 4 presents a conceptual map outlining the key themes and subthemes related to teacher

educators' technology leadership, which are elaborated in detail in the following paragraphs.

Figure 4
Conceptual Map on Teacher Educator Technology Leadership



Definition of Teacher Educators' Technology Leadership

Innovation and Modeling

For teacher educators to be acknowledged as technology leaders, they must not only be able to integrate technology effectively, but they should also be the instigators of innovation, should be enthusiastic about technology's pedagogical role in the classroom, and should be willing to engage in ongoing curriculum and professional development to stay current with technology trends and changes (Starčić & Lebenicnik, 2020). Howell et al. (2014) defined technology leaders as those who provide teacher educators with resources such as encouraging ongoing professional development, networking, and participation in learning communities. "Leaders should strive to create a culture that supports technology experimentation and collaboration among peers" (p. 33). Leadership is important because it is the building block upon which a community of practice surrounding effective pedagogical technology integration is built.

Continuous Learning and Professional Development

While teacher educators who act as technology leaders are known to possess certain attributes that make them so, those teacher educators who desire to be leaders can develop those attributes with ongoing professional development and practice. This process, in turn, directly influences

teacher candidates as they progress with technology integration leadership in their future classrooms. This finding reiterates the concept of continually learning about new technology concepts and practices as they are developed for education and of providing and participating in ongoing professional development to transfer this information. Schuck et al. (2012) discussed the idea of teacher educators' participation in professional learning communities as a way to provide the support needed to develop new technology skills and pedagogical directions in their teaching with technology.

Best Technological Practices of Teacher Educators

The second research question addressed teacher educators' best practices in leading technology integration to enhance teacher preparation. Our analysis of the included studies showed that these technology leadership initiatives center around four major themes, which are leveraging the TPACK model, artificial intelligence (AI), simulation technologies, and online space to enrich teacher education.

The TPACK Model

Among those four major topics, infusing the TPACK model into teacher education programs attracts most of the research attention. Teacher educators' practices in integrating TPACK range from the revision of an existing course to the design of new courses (Baran & Uygun, 2016; Coker et al., 2024). In terms of course revision, Galanti et al. (2021) described how four mathematics teacher educators applied TPACK and redesigned performance-based assessments in a synchronous graduate geometry and measurement content course to offer in-service teachers, coaches, and specialists with assessment ideas that could be adapted in their online teaching.

In a similar vein, Carpendale et al. (2020) reflected on how they, as teacher educators from three different Australian universities, revised the units and delivery format of their chemistry courses due to the need to shift classes online during the COVID-19 pandemic. Through an analysis of their own experiences in course revision and teaching online, they demonstrated how to explicitly model TPACK for chemistry learning, which in turn, "more effectively develops the TPACK of preservice teachers" (p. 2540).

In a recent study, Lim et al. (2024) explored preservice teachers' TPACK development after completing two technology integration courses in early childhood education. Those two courses were designed to incorporate multiple technologies aligned with the curriculum and learning objectives to foster preservice teachers' knowledge and skills in TPACK. Through an examination of survey, reflection, and focus group data collected from 22 preservice teachers, Lim et al. reported significant increases in preservice teachers' positive attitude toward educational technology and pedagogy and their overall TPACK scores.

Online Space

In addition to best practices in implementing the TPACK model, teacher educators harness various technologies to create engaging and meaningful online spaces to facilitate preservice teachers' critical reflection and enhance practicum experiences. One example is Clark et al.'s (2016) use of international videoconference discussions to enrich preservice teachers' critical reflection. Specifically, the researchers explored the use of online discussions between four in-service teachers and 23 secondary social studies preservice teachers in an instructional methods course, with one researcher also serving as the instructor. The study results showed that integrating videoconference discussions into the existing course deepened preservice teachers' critical reflection in four areas: effective use of technology, multicultural and inclusive education, censorship of online resources, and accountability of assessment issues.

Apart from using online spaces to foster critical reflection, Chan (2020) investigated how online mentoring helped preservice teachers navigate practicum tensions. Through the creation of an online mentoring community during an 8-week practicum block, the researcher offered additional mentoring support to preservice teachers enrolled in initial teacher education programs. Specifically, Chan focused on analyzing interviews and online conversations in one mentoring group consisting of one English as a second language (ESL) preservice teacher and four virtual mentors who were all in-service ESL teachers from various local primary schools. The study found that structured online space mentorship "offered a safe alternative space for the mentee to share difficult teaching problems and dilemmas" and for the mentors to learn from each other as well (p. 197).

Unlike Chan's (2020) emphasis on online mentoring, Kidd and Murray (2020)'s research explored 14 teacher educators' transition to online practicum learning during the COVID-19 pandemic. In spite of challenges in technology access and teacher educators' varying digital competence, the researchers reported that teacher educators demonstrated pedagogic agility in redesigning curricula and teaching methods to pivot the traditional practicum to online experiences. Their innovative exploration and application of digital tools led to the creation of a new online learning space that connected preservice teachers with teacher educators and mentors and engaged preservice teachers in reflective practices.

Simulation Integration

Further, teacher educators have played leadership roles in exploring how simulation technology could be integrated into courses to enhance teacher preparation. Lew et al. (2021), for instance, examined how teaching in simulation sessions embedded in an introductory English speakers of other languages (ESOL) course helped boost preservice teachers' culturally responsive teaching. Their study recruited six preservice teachers who were undergraduate traditional and nontraditional students seeking an elementary and exceptional student education degree. Only three students completed the interviews, however, and all simulation sessions involved the preservice teachers teaching lessons and interacting with five avatar students in a virtual classroom.

Through their interview and observation data analysis, Lew et al. (2021) reported that all three preservice teachers considered simulative practice as very beneficial, which provided them with a high level of interactivity with the avatar students and served as a useful tool for self-assessment. Meanwhile, they also noted a major limitation of the simulation: The avatars could neither engage in any physical movement nor perform hands-on activities.

In comparison, Landon-Hays et al. (2020) redesigned several key courses in both special education and secondary education programs to integrate learning experiences via a simulation environment to enhance preservice teachers' teaching practices. By conducting five Mursion simulation sessions, the researchers investigated 36 preservice teachers' high-leverage practices, with 19 in special education and 17 in general education at the secondary level. Their studies found that simulation learning helped boost preservice teachers' self-efficacy in collaborating with their teaching partners, developing goals for future teaching, providing differentiation to satisfy student needs, and increasing self-reflection on teaching.

AI Perceptions and Literacy

Last but not least, some recent studies have revealed how teacher educators led efforts in integrating AI tools into teacher education courses and examined the impact of this new technology on preservice teachers' perceptions and learning. For instance, Yang and Appleget (2024) investigated 56 preservice teachers' perceptions of Generative AI (GenAI), who were enrolled in elementary literacy methods courses at two universities. Their study results indicated that many preservice teachers perceived GenAI as a helpful tool for teachers. Eighty percent of the preservice teachers reported positive attitudes toward using GenAI to create questions, and 71% were likely or highly likely to apply GenAI in their future teaching practice. Despite preservice teachers' support in GenAI, they also expressed concerns about the adverse influence that might be brought about by GenAI, such as restraining the creative teaching process and teacher agency.

Hur (2024), on the other hand, infused AI literacy lessons into an existing technology integration course that was taken by students in four majors, including elementary education, early childhood education, secondary social studies, and special education. Through data analysis of 46 preservice teachers, they found that the revised course increased both preservice teachers' knowledge and awareness of AI teaching. Echoing Yang and Appleget's (2024) findings, Hur's study revealed that preservice teachers were also concerned about teacher replacement by AI, and students' critical thinking may be negatively affected by AI incorporation, even though they recognized the educational benefits of AI.

Critical Attributes of Technology Leaders

Regarding the third research question, we identified that teacher educators who possess critical attributes can be role models for teacher candidates. These attributes encompass their beliefs in the positive effects of technology integration, confidence in their technological abilities, and engagement in learning to expand their horizons (O'Neil & Krause, 2019).

For example, several included studies revealed that educator leaders either already possessed critical attributes that enabled them to serve as role models for teacher candidates or recognized the need to develop such attributes with university support. Many not only expressed strong beliefs that technology applications can empower meaningful learning and student agency but also could demonstrate high levels of confidence in modeling effective instructional practices and leveraging technology tools to align with content standards and create authentic learning experiences for students.

Taimalu and Luik (2019) noted attributes or personal characteristics possess by teacher educators that can predict how they prepare candidates and exercise leadership in this process. These seem to indicate the degree to which teacher educators model and teach with technology. Ranging from basic recognition to incorporating technology skills into teacher candidate preparation in a constructivist manner, teacher educators play a necessary part in the development of these practices for teacher candidates with whom they work.

Importance of Technology Leadership

Technology use in education is more important and pedagogically useful than ever before. Frequent changes in technology demand awareness of ways to use it better to diversify and pedagogically assist in the development of curriculum and the execution of content. Those who have a direct impact on this practice are teacher educators at the university level who work with and prepare candidates to educate effectively and in a timely manner in classrooms.

Influence on Teacher Candidates

The way technology associated with learning is presented by teacher educators to candidates will influence teacher candidates' "attitudes toward and work with technology in the classroom" (Taimalu & Luik, 2019, p. 101). Taimalu and Luik also referred to their research when looking at this integration through four key variables: teacher knowledge, self-efficacy, pedagogical beliefs, and content and school culture (p. 102). These are critical areas of consideration when looking at the attitudes and proficiencies of teacher educators, and with that recognition, there are universities and organizations making efforts to cultivate and hone those areas of concentration for their teacher educators.

First of all, teacher educators need to see and believe in the value of using technology in pedagogical situations. Taimalu and Luik (2019) found that teacher educators' constructivist pedagogical beliefs influenced their beliefs on the integration of technology (p. 107). Second, Clausen et al. (2023) contended from their study that teacher educators need even more than belief. Teacher educators also need a positive attitude toward technology, confidence in how they model technology, self-efficacy, adaptability, and strategic thinking.

Competencies to Guide Integration

The Teacher Educator Technology Competencies (TETCs) were developed by Foulger et al. (2017) to give substance to the expectations for teacher educators and competencies that were necessary for developing the practices of future teachers. The TETCs focus on 12 key areas: technology integration, curriculum design, assessment, digital citizenship, professional development, leadership and vision, collaboration, research and evaluation, content knowledge, pedagogical knowledge, technology knowledge, and contextual knowledge. Though the list seems extensive, these surface as critical attributes for teacher educators who are directly working with teacher candidates. These twelve attributes are crucial for shaping teacher educator mindsets and practices.

Foulger et al. (2017) considered the TETCs as a measure of teacher educator attributes for integrating technology into technology programs. They observed, “Currently, in the majority of teacher preparation programs, a semester-long course is the approach used to help teacher candidates learn how to teach with technology...” (p. 416). Instead, it is more effective for teacher education programs to infuse technology throughout the coursework completed by candidates. “A key component that remains constant for effectively preparing teacher candidates to use technology is the involvement and influence of the teacher educator” (p. 417). This is the reason the TETCs are so critical as competencies and guidelines to measure attributes of the teacher educators.

The TETC’s focus areas are reiterated in the study by Knezek et al. (2019), who surveyed 223 teacher educators across North America, Europe, and the Asia/Pacific during 2018-19. One theme that surfaced in their study was the need for teacher educators to be proactive and work to advance their own skills and self-efficacy. One third of the survey participants were at a conference, part of the Society for Information Technology in Education, so it was thought that the results might be higher in their technological competencies because of their participation in such a group. As Knezek et al. analyzed the credibility and relevance of the survey, they recommended it as a possible measure of the confidence of teacher educators in modeling the use and integration of technology when working with teacher candidates.

Another set of standards, the ISTE (2017) standards, provides guidelines for educators to integrate technology and should be yet another way that teacher educators can influence and train practicing teachers to integrate technology into their pedagogical practices. These standards categorize educators into different modes of integration: learner, leader, citizen, collaborator, designer, facilitator, and analyst.

Modeling technology integration is an important quality, but the ability to design curriculum and choose appropriate tools based on content is an important piece. Also, showing initiative in seeking out new trends and knowing how to choose tools pedagogically are important, too. Finally, not only having technical knowledge but also being able to model ethical and responsible use of technology and understanding the demographics and resources available to appropriately integrate technology are critical (Foulger et al. 2017).

Professional Development Considerations

The *InTASC* (Interstate Teacher Assessment and Support Consortium) *Model Core Teaching Standards* (Council of Chief State School Officers, 2011) and Council for the Accreditation of Educator Preparation standards (2022) both referenced the preparation and integration of technology within teaching and learning. These standards are another confirmation that having teacher educators who can effectively guide teacher candidates to integrate technology in their future classrooms is critical (Foulger et al., 2017).

Dillon et al. (2019) referenced a study that sought to address the gap in technology integration preparation at the University of Minnesota with a Teacher Educator Technology Integration Initiative. Three components of that study concentrated on the teacher educators' impact of developing trusting relationships for coaching, situated learning experiences, and professional development that aimed to develop and foster positive attitudes toward technology use. The results of this study indicated that ongoing professional development and effective coaching brought about a position as an instructional technology coach who could serve as a role model to teacher educators and encourage their progress forward.

As a result of the study, 9% of teacher educators who participated rated their own competency as competent or outstanding, as opposed to 30% when they completed the post survey (Dillon et al., 2019). Though the tools used and the methods of use varied across content disciplines, many teacher educator participants continued with professional development and expanded their awareness of possible pedagogical applications of technology. As a result of this coaching, the study found that teachers became more comfortable with using the technology if they worked with a coach that they trusted (Dillon et al., 2019, p. 549).

Instefjord and Munthe (2017) contended that for effective integration teacher educators must possess not only technological knowledge but also sound pedagogical knowledge and that a strong correlation could be drawn between teacher educators' self-reported efficacy and their digital competence. Only 35% of the teacher educators in their study believed in themselves as good role models, and their practices directly affected teacher candidates and the ways they approached integration in their future classrooms.

Teacher educators are not always confident in their abilities to integrate technology effectively (Aziz & Quraishi, 2018), but by calling attention to the attributes necessary for effective integration, universities can make changes in teacher education programs to better prepare educators, which will have a direct effect on teacher candidates. Given the current technological climate and the rapid pace of change, it is critical that even teacher educators who already demonstrate some of these attributes continue to develop them, and those who are less confident must be provided with the ongoing professional development and support to move forward.

Contextual Factors on Technology Integration

In respect to the fourth research question, we found that technology leadership in teacher education is influenced by a complex interplay of external factors — operating at institutional, programmatic, and cultural levels — that shape the environment in which teacher educators work, alongside personal attributes such as internal beliefs and pedagogical orientation (Clausen et al., 2021, 2023; Carpenter et al., 2024; Dillon et al., 2019; Instefjord & Munthe, 2017; Liu et al., 2015; Zehra, 2021). Together, these elements determine the opportunities and constraints for meaningful technology integration in teacher preparation programs.

Institutional Influences

Institutional support for developing technology competency emerged as the most frequently cited external influence on technology leadership (Aziz & Quraishi, 2018; Carpenter et al., 2024; Dillon et al., 2019; Gondwe, 2021; Instefjord & Munthe, 2017; Zehra, 2021). For example, Carpenter et al. found that teacher educators develop and enact their competencies through institutional support, which includes support for ICT infrastructure, professional development opportunities, and alignment with national educational technology policies. Additionally, Aziz and Quraishi suggested that there appears to be broad agreement regarding need for more structured and systematic training for teacher educators and that professional development programs should incorporate innovative approaches to ensure teacher educators are effectively prepared to train future teachers.

Factors also included limited leadership vision, weak policy frameworks, and insufficient incentives or budget allocations, all of which hinder faculty engagement in technology leadership (Clausen et al., 2023; Carpenter et al., 2024). Moreover, time was the most frequently cited barrier. Faculty members reported that designing and delivering technology-enhanced instruction demanded an incredible amount of time, which influenced teaching quality and work-life balance, especially with the absence of institutional support (Howell et al., 2014; Liu et al., 2015; Instefjord & Munthe, 2017). One of Liu et al.'s (2015) participants mentioned, "Given my hectic schedule, I have no spare time to design digital materials using PowerPoint software" (p. 167).

Programmatic Challenges and Mentor Teacher Readiness

Concerns were widely shared about the integration of technology in teacher education curricula. Specific challenges included lack of iterative practice-based coursework, weak alignment with ISTE (2017) standards for educators, disconnect between preservice training and P-12 school realities, and inadequate program assessment structures. Clausen et al. (2021) and Clausen et al. (2023) found that program design was a key factor in technology infusion to ensure adequate teacher preparation and to enhance P-12 learning, including iterative practice by candidates and programmatic assessment of candidate use of technology in teaching and learning.

Clausen et al. (2023) suggested that “challenges remain to infusing technology in program-deep and program-wide curriculum and experiences for teacher candidates’ preparation” (p. 34). Additionally, mentor teachers often lacked the technological fluency of their preservice mentees, yet this created an opportunity for reciprocal learning. Liu et al. (2015) found that preservice teachers’ innovation sometimes influenced mentor adoption of new tools. However, effective technology leadership was supported by structured continuing professional development involving teaching cycles, observation, and reflection.

National and Cultural Influences

In countries like Estonia, government-mandated e-learning policies enhanced faculty members’ digital literacy and technology leadership capacity. Tømte et al.’s (2015) study revealed that, even if online teacher education programs represent promising avenues for stimulating teachers and student teachers to develop digital competence for pedagogical purposes, this aspect is poorly integrated within the programs. Additionally, Liu et al. (2015) noted that cultural tendencies toward individualism, such as those observed in Taiwan, limited collaboration and reduced the efficacy of professional development.

Discussion and Implications

Given the absence of a shared vision for technology leadership in teacher education contexts, our review unraveled the definition of technology leadership, teacher educator leaders’ essential attributes, and best practices in infusing technology in teacher preparation, as well as contextual factors that might shape these leaders’ technology integration efforts. Our study not only confirmed the importance of teacher educators’ leadership role in modeling and transferring their technological knowledge and skills in preparing preservice and in-service teachers, but also shed light on assets and barriers that could empower and restrict the leadership roles played by teacher educators.

The following section discusses our findings in four areas: the definition of teacher educators’ technology leadership, best practices in leading technology integration, attributes of technology leaders, and influencing contextual factors. Additionally, the current study offered implications for future research to expand the conceptualization of teacher educators’ technology leadership through empirical and interdisciplinary inquiry and to restructure teacher education programs through their leadership.

Discussion About the Definition of Teacher Educators’ Technology Leadership

We found a scarcity of research that directly defines technology leadership in teacher education contexts. Consequently, the existing literature does not provide an adequate basis for developing a comprehensive definition, underscoring the need for future research. To address this gap, we proposed a functional definition of teacher educators’ technology leadership grounded in our thematic analysis. Specifically, we defined technology leadership as the capacity of teacher educators to assume

leadership roles in guiding the integration of technological tools and practices to strengthen teacher preparation, shaped by the interplay of individual attributes and contextual factors. This capacity entails (a) actively initiating and supporting technological innovations within and across teacher education programs, (b) systematically exploring and modeling the pedagogical applications of technology in classroom contexts, and (c) demonstrating a sustained commitment to curriculum redesign and professional development to ensure alignment with evolving technological advancements.

By advancing a functional definition, our study contributes conceptual clarification by specifying what teacher educators actually do when enacting technology leadership in the context of teacher preparation. In contrast to generic educational leadership models that often emphasize administrative functions (e.g., Leithwood & Jantzi, 2005), our definition highlighted three interrelated functions alongside the pedagogical and programmatic practices distinctive to teacher educators' work, while also emphasizing how various internal and external factors can impact their leadership in technology integration.

Discussion About Best Practices

As evident from our analysis, teacher educators' leadership in technology integration differed not only in the types of practices but also in the scope of their application. In recent years, the types of such practices have been largely driven by the COVID-19 pandemic and emerging innovative simulation and AI technologies. Due to the pandemic, many teacher educators were forced to pivot their classes online and were challenged to adapt quickly to the new learning environment, even though they had various background experiences and expertise in infusing technologies (Carpendale et al., 2020; Kidd & Murray, 2020).

During this period, teacher educators actively applied TPACK as the framework for their course revision or redesign. They also modeled its meaningful application in their online classes, so that preservice teachers and in-service teachers could enhance their TPACK competence and access good quality examples of learning materials and assessments that could be easily adapted for their daily teaching. Additionally, teacher educators took advantage of videoconferencing and web-based forums to create online spaces to connect students in teacher education programs with their university supervisors and cooperating teachers who were physically isolated from each other due to COVID-19 emergencies.

In the post-pandemic world, although many teacher educators have switched back to in-person teaching, they have kept seeking innovative ways of infusing emerging technologies in teacher education programs. Along with their continuous efforts in leveraging the TPACK model and online spaces to enhance teacher education, teacher educators have explored new simulation and AI technologies in undergraduate and graduate courses, such as introductory ESOL courses, technology integration courses, and literacy methods courses (Hur, 2024; Landon-Hays et al., 2020; Lew et al., 2021; Yang & Appleget, 2024).

In particular, with AI's increasing potential to reshape the educational realm, teacher education programs are required not only to keep abreast with this new technology but also to seek out meaningful ways to leverage it in preparing future teachers. Our study results corroborated previous research findings in acknowledging AI's promise as a helpful educational tool that could be harnessed to enrich teaching and learning (Bond et al., 2024; Fu et al., 2024).

Meanwhile, our study also confirmed the negative impact that could be generated by inappropriate AI use, such as plagiarism and loss of critical and creative thinking skills due to AI misuse (Hur, 2024; Yang & Appleget, 2024). Thus, teacher educators are challenged to develop instruction, learning activities, and materials, as well as professional training, that directly teach responsible human-centered AI practices, so preservice teachers and in-service teachers can be better prepared and trained to enhance their awareness, knowledge, and skills in effectively and ethically applying AI in their classrooms (Fu & Weng, 2024; Karataş & Yüce, 2024; Mouta et al., 2025).

Regarding the scope of technology integration, teacher educators' practices ranged from revising one existing course (e.g., Carpendale et al., 2020; Galanti et al., 2021) to restructuring multiple courses in teacher education programs (e.g., Landon-Hays et al., 2020; Lim et al., 2024). Despite the wide variety of redesign efforts displayed by teacher educators, most practices of technology integration were focused on improving an existing course, including revisions of existing assessments, lessons, learning activities, or delivery format. By contrast, a scarcity of studies included in our review was focused on systematically redesigning several courses within one teacher education program or across the programs with leadership efforts. To strengthen teacher educators' technology leadership and empower them to implement technology integration beyond their individual courses, we call for institutional policies and support that can guide systematic restructuring of assessments, curriculum, and program design involved in teacher preparation.

Discussion About Attributes

All of this attention on training in and development of technology integration for teacher educators has been brought to the forefront because "we do a disservice to our teacher candidates if we do not possess the very competencies we are working to develop in them" (Parrish & Sadera, 2019, p. 438). With reference to the TETCs, it is important to recognize the roles and responsibilities of teacher educators who have such a direct impact on the future practices of teacher candidates. Since trends suggest that teacher educators lack the ability to integrate technology effectively into the coursework they design for teacher candidates and are even less familiar with current technologies, the TETCs are a way to further develop the basic attributes of teacher educators so that they can serve as role models for effective pedagogical technology integration.

It was previously believed that these attributes, or the lack thereof, were in some way systematic, but technology-related decisions have been found to be more dependent on individual teachers' choices (Parrish & Sadera, 2019). That is why the development of competencies and a concentrated

effort to build them up in teacher educators with ongoing practice and professional development is so important. Among such efforts, “successful faculty development programs are those which emphasize how technology can be used to support students and assess outcomes while also providing choice to faculty members” (p. 459). Teacher educators can then become the role models needed to provide technology leadership for their teacher candidates.

Discussion About Contextual Factors

As evident from our analysis, technology leadership in teacher education is shaped by a complex interplay of contextual forces beyond the control of individual teacher educators, yet these forces profoundly influence their ability to act as leaders. While teacher educators are expected to model effective technology integration and mentor preservice teachers, their leadership capacity is constrained by systemic barriers.

External factors — such as limited institutional support, inadequate infrastructure, weak leadership vision, and fragmented curriculum design — restricted opportunities for teacher educators to demonstrate leadership in digital pedagogy (Carpenter et al., 2024; Clausen et al., 2023). Programmatic challenges, including a misalignment with ISTE (2017) standards, insufficient iterative practice, and the absence of technology-focused mentor teachers, further limited their ability to prepare future teachers as confident technology users and leaders (Clausen et al., 2021, 2023).

At the same time, broader cultural and policy contexts directly shaped the scope of teacher educators’ leadership. For example, Estonia’s national strategies created conditions that enabled faculty members to enact leadership by advancing digital competence (Tømte et al., 2015), whereas professional isolation in Taiwan constrained collaborative leadership opportunities in professional development (Liu et al., 2015). Across contexts, the lack of time — exacerbated by insufficient institutional recognition — reduced teacher educators’ ability to take initiative or sustain leadership in technology integration (Howell et al., 2014; Instefjord & Munthe, 2017; Liu et al., 2015).

These findings highlight that teacher educator leadership in technology is not simply a matter of individual choice or skill, but one that requires systemic alignment and institutional commitment. Without addressing these structural and cultural barriers, teacher educators’ potential to lead technology integration and prepare future teachers for digital-age classrooms remains severely limited.

Implications for Future Research

This section outlines key directions for future studies, highlighting the need to broaden how teacher educators’ technology leadership is understood, defined, and examined through interdisciplinary and empirical research.

Expanding Conceptualization

To develop a more comprehensive definition, future studies can be geared toward probing the meaning of teacher educators' technology leadership by conducting empirical research to collect and analyze data from teacher educators, ICT staff, administrators, and students who are enrolled in teacher education programs. In addition, researchers can draw on interdisciplinary literature examining higher education instructors to inform and enrich the conceptualization of teacher educators' technology leadership, given that limited studies are solely focused on teacher educators.

For instance, Olaniyan and Uzorka (2024) examined leadership responsibilities involved in facilitating faculty technology integration in 10 educational institutions. They stated that "a strong vision and strategic direction for technology integration projects in educational institutions are essential components of effective leadership" (p. 471). Olaniyan and Uzorka further emphasized that the success of such projects depends on leadership. Effective technology leaders, they argued, model optimism for technology integration, see obstacles as opportunities for development and growth, and provide ongoing examples of innovation and learning. Critically examining studies like this may enhance insight into teacher educators' roles and responsibilities as leaders in technology integration.

Restructuring Teacher Education

Though many teacher education programs have added technology integration to their preparation requirements, the ways in which students are prepared vary considerably across institutions. Some programs adopt a comprehensive approach by infusing technology throughout their education courses, thereby enhancing teachers' meaningful and pedagogically sound integration. In contrast, others rely heavily on a single, stand-alone educational technology course, which may offer insufficient opportunities for teachers to develop contextually relevant technology skills. In spite of longstanding concerns about its inadequacy for promoting in-depth TPACK knowledge and skills, the stand-alone technology course model remains widely used in teacher education programs (Tondeur et al., 2013).

Further research is needed not only to examine the levels of technology integration in teacher preparation programs but also to inform reforms that support more intentional and coherent training across coursework and field experiences to better prepare future educators entering the classroom. Additionally, it is essential to explore effective and innovative ways to hold teacher educators accountable to national or institutional technology standards, ensuring they model the competencies teachers are expected to build. This, in turn, will enable teacher education programs to equip teachers to navigate and thrive in increasingly technology-rich learning environments.

Limitations

Though we attempted to make our search process as comprehensive as possible, the current study had three limitations. First, this systematic review centered on peer-reviewed journal articles from Scopus, WoS, Eric, PsycINFO, and Google Scholar. Thus, we excluded journal articles from other databases as well as other types of literature from our review, such as book chapters, conference proceedings, and grey literature. Second, most of the included studies were conducted in the US, followed by the UK, Norway, and Australia. Thus, the results of the current study were heavily impacted by research findings from those leading countries. Third, our study might not encompass all studies on teacher educators' technology leadership, given that a clear definition of the term was not well established in the existing literature.

Conclusion

This systematic review synthesized insights from 29 studies published between 2010 and July 2024 to clarify the concept of teacher educators' technology leadership, highlight best practices in technology integration, identify essential leadership attributes, and examine contextual factors that influence this work. Our analysis indicates that teacher educators play a pivotal role not only in preparing preservice and in-service teachers to use technology but also in modeling innovation, shaping curriculum, and fostering digital competencies that are critical for 21st-century teaching and learning.

By advancing a functional definition of technology leadership in teacher education, this review contributes much-needed conceptual clarity and provides a foundation for future empirical and theoretical work. The findings underscore that effective technology leadership requires more than individual enthusiasm and skill; it depends on sustained institutional support, coherent program design, culturally responsive policies, and opportunities for continuous professional development. Without such systemic alignment, teacher educators' ability to act as technology leaders will remain constrained.

Ultimately, strengthening teacher educators' technology leadership is essential for ensuring that the next generation of teachers enters the profession prepared to integrate digital tools thoughtfully, ethically, and effectively. This review calls for further interdisciplinary and international research to refine the construct of technology leadership in teacher education, examine how diverse contexts shape leadership practices, and explore strategies that can embed technology leadership across teacher preparation programs. By doing so, the field can move toward more inclusive, innovative, and sustainable models of teacher education that empower both educators and learners in increasingly digital learning environments.

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