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Article

Finding Spaces: Teacher Education Technology Competencies (TETCs)

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Abstract: This article explores technology's integration, assessment, and reflection within a single secondary education program at a Mountain West university. In light of the publication of the Teacher Education Technology Competencies (TETCs), faculty members of a secondary education program focused on existing practices and pathways for expansion to better align with the TETC standards in the future. The purpose of this study was to explore existing practices of incorporating technology into secondary methods coursework and to search for new spaces to implement the TETC guidelines and structure, as well as explore the roles faculty play in the adoption and implementation of technologies. Vignettes authored by faculty in each content area provide a rich depth of faculty experience and dispositions regarding technology integration, as well as spaces for the deeper use of technology based on the TETC recommendations. Key questions emerged about the efficacy of current technology practices, as well as the experiences and dispositions of the faculty within the secondary education program. Findings show that secondary education faculty use domain/content-specific technologies in their course; are expected to be "meta-experts", both discovering and implementing technology simultaneously; and tend to discover technologies through content-specific interactions and discussions.

Keywords: technology; teacher education; methods courses; teacher education technology competencies (TETC); integration; preservice teachers; information and communication technologies (ICT)

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1. Introduction

How do teacher educators prepare future teachers to effectively integrate information and communication technologies (ICTs) in their classrooms? This overarching and perplexing question has prompted professional organizations to focus on preservice teachers' experiences with technology in the classroom, suggesting technology standards for preservice teacher preparation, both broad (e.g., ISTE) and content-specific (e.g., NSTA) in scope [1,2]. With the introduction of the Teacher Educator Technology Competencies (TETCs), specifically designed for teacher educators, another dimension has been added to the conversation.

By proposing general and content-specific technology integration, the TETCs represent an overarching framework to guide teacher education programs and departments [3]. In this article, teacher educators explore current and future ideas for technology use in their secondary methods coursework through the TETC framework. This article is meant to capture current practices and look for spaces to improve through the TETC best practices. Central to this study is the differentiation between general-purpose education technology (i.e., learning management systems, email, whiteboards, presentation applications, etc.) and more content/discipline-specific technologies utilized in preservice teaching methods courses.

In this article, the authors explore the TETC framework, describe how they presently integrate a variety of content-specific technologies into their secondary methods courses, and how they envision adapting these technologies and processes within the developments of the TETC framework (TETC; site.aace.org/tetc) (accessed on 28 October 2021). The purpose of this study was to compare existing practices regarding the incorporation of technology in the classroom in secondary methods courses to the newly released TETCs. This article encapsulates the current practices and approaches as well as the future integration of the TETC concepts to improve the practice and integration of technology into secondary methods coursework. Through faculty-perspective vignettes about current and future technology integration, the aim of this paper is to show how one secondary education program thinks about and incorporates technology, and eventually the TETC framework, with secondary education preservice teachers.

2. Teacher Educator Technology Competencies (TETC)

Like almost every industry or profession, teacher education programs have wrestled with the rapidly changing societal reliance on domain-specific technologies and the need for educational programs and practitioners to adapt to those technologies [4]. This has increased tensions in how teachers do their professional work and training and has reverberated into all levels of teacher preparation programs and colleges of education in the US and abroad. Now immeasurably amplified by the impact of COVID-19 in schools and universities around the world, ICTs have introduced a profound shift in how we deliver, design, and facilitate teaching and learning in preservice teacher education programs. These tensions among teachers, teacher educators, and preservice teachers have led to an uneven adoption and understanding of ICTs and how they can be utilized in various content domains [5].

There are many moving parts in teacher education environments, and the current TETCs were conceived as a way to move the conversation forward. The TETC framework allows faculty and program directors to begin to address the many layers of the sluggish incorporation of technology into teacher education on all levels. In outlining the competencies, Foulger, Graziano, Schmidt-Crawford, and Slykhuis [4] explain:

The TETCs should be viewed as the first step in a larger reform effort to better address technology integration in teacher preparation programs. The release of the TETCs provides future research opportunities, including, but not limited to, implications for course design, relevant faculty development for teacher educators, and policy implications (p. 413).

Specifically, the TETCs indicate that teacher educators should model and integrate technology in 12 interwoven ways:

1. Design instruction that utilizes content-specific technologies to enhance teaching and learning;
2. Incorporate pedagogical approaches that prepare preservice teachers to effectively use technology;
3. Support the development of the knowledge, skills, and attitudes of preservice teachers as related to teaching with technology in their content area;
4. Use online tools to enhance teaching and learning;
5. Use technology to differentiate instruction to meet diverse learning needs;
6. Use appropriate technology tools for assessment;
7. Use effective strategies for teaching online and/or in blended/hybrid learning environments;
8. Use technology to connect globally with a variety of regions and cultures;
9. Address the legal, ethical, and socially responsible use of technology in education;
10. Engage in ongoing professional development and networking activities to improve the integration of technology in teaching;
11. Engage in leadership and advocacy for the use of technology;
12. Apply basic troubleshooting skills to resolve technological issues (see further details at site.aace.org/tetc) (accessed on 28 October 2021).

It is important for teacher educators to understand that the TETCs are intended as a holistic reform movement for further conversation and critique, especially as these competencies are explicitly linked to the layers and demands present in and part of teacher education programs. This article sheds light on how one teacher education program, at a large Mountain West university, is currently using technology in teacher preparation and how the teacher educators and preservice teachers plan to continue to wrestle with technology implementation in relation to the TETCs. The authors intend this article to further the discussion about the beginnings of the TETC framework as well as show that in-depth technology work in teacher education programs is filled with complications and challenges.

3. Literature Review

The incorporation of ICTs into university-based teacher education programs, as with K–12 schools, is full of divergent practices and beliefs which often occur consistently but unpredictably. Teacher educators gain experiences with different ICTs over the course of their careers and ultimately teach in institutions with variations in attitude, knowledge, and structure informing the use and application of ICTs. Similarly, K–12 school teachers incorporate technology in irregular ways within their teaching practices, which can be linked directly to pedagogical practice and "comfort levels" with technology and data [6]. These pedagogical beliefs in both teacher education and in K–12 settings have been shown to play a major part in possibilities for technology use and can greatly influence practices and understandings among educators [4,7].

Teacher educators' varied beliefs, program requirements, and institutional structures have influenced teacher education programs and the incorporation of ICTs, resulting in this unevenness. These variations can lead to preservice teachers experiencing conflicting viewpoints about technology use in the classroom, and these views can be enabled or disabled by their experiences with mentor teachers and teacher educators [5,8–10]. In most teacher education programs, there is a singular course or series of courses meant to encompass "general purpose" instructional technology, such as learning management systems, word processing, web design, and presentation software (e.g., teaching with technology). This has led to the often-widespread belief that technology use is "low level," or administrative, with K–12 schoolteachers who are uncomfortable with more advanced technology and data use with regard to enhancing student learning [8,9].

As for teacher educators' beliefs and dispositions, some view 21st-century students as "digital natives", mistakenly believing that preservice teachers will proficiently use teaching technologies in the classroom as a result of their own experiences in the personal use of ICTs. However, research shows that the "natives" are mostly able to use familiar, "light" technologies, such as social media applications, but have not learned to use technology or advanced applications in robust ways [11]. To address the disconnect in teacher education programs, the TETCs were developed to incorporate technology throughout teacher education courses and field experiences by focusing on the teacher educator, with aims to "infuse" disciplinary work with complementary technology experiences and applications [3].

4. Gaps in the Literature

Research in education using the TETCs is still novel. More studies about the inclusion of the TETCs into teacher education programs, courses, and field placements, as well as how faculty and students perceive the competencies, are warranted. Some recently published studies involving the TETCs include work toward developing an instrument to measure student perceptions of the competencies, an exploration of the intercultural focus of TETC standard 8, a study linking ISTE and TETC standards, and an exploration of preservice teacher perceptions of technology and skills in the classroom [12–15]. One study also looked at the inclusion of the TETC standards into an elementary mathematics course, while another surveyed preservice teachers' self-efficacy in incorporating technology through the use of the TETCs [16,17]. To add to the literature, this article explores one teacher educator program's use of technology in methods classrooms and the challenges in developing and facilitating robust, domain-specific, discipline-focused technology use within the TETC framework. The teacher educators of the entire secondary education program at a large Mountain West university contributed to this article, with key insights into the challenges and opportunities of incorporating technologies into teacher education programs, as well as envisioning future ICT usage through the TETC lens. One of the key bottlenecks in technological knowledge and use is teacher educator "expertise". While teacher educators bring years of training and research experience from their fields, most incorporate technology as a pedagogical tool, much like the K–12 school teachers described above.

While most teacher educators value the use of technology in teacher education, the ways that these values are practiced differ in nuanced and important ways [18]. With regard to the TETCs, teacher educators are teachers themselves, working with curriculum materials, teacher education standards (i.e., InTASC, CAEP), and content expertise, and so teacher education faculty must also incorporate and use domain-specific technology at expert levels with their preservice teachers. There has been little research conducted to explore the key components of teacher educator practice with regard to technological knowledge, aptitude, and pedagogy. Specifically, there is a gap in the research regarding how teacher educators operate as "second-order" teachers. This "second-order" role must be attuned to explaining certain pedagogical and curricular decisions while modeling teaching behaviors when it comes to technology use in preservice classrooms [19]. There is also a lack of technology competencies research regarding professional development or institutional support for the use and understanding of technology by teacher educators. In fact, there are no current research studies exploring the professional development experience for teacher educators in technology pedagogy, knowledge, and competency [19].

5. Methodology

The authors of this study wanted to examine the TETCs in order to purposefully infuse university teacher education programs with the teacher education technology standards. For this reason, the authors chose their secondary methods courses for analysis, as these courses are the ultimate spaces for preservice teachers to demonstrate their expertise in incorporating technology and technological practices into their teaching discipline. Exploring existing practices in the courses and looking to improve these practices through the TETC lens, the authors' set out to explore current practices and attitudes about technology in secondary teacher education programs and find opportunities in these programs to utilize the TETC framework in future courses.

This article showcases a comprehensive view of a collective teacher education program (consisting of varied content areas in secondary education) and how the teacher educators involve, incorporate, and facilitate domain-specific technology in their methods classrooms. Teacher educator knowledge, and beliefs about technology in the university classroom, as well as future structural changes that can benefit preservice teachers through utilizing the TETCs, are also explored.

5.1. Research Questions and Study Design

All of the participants in this study are teacher educators or university faculty from a secondary education program at a large Mountain West university. Each author has taught methods courses in the content discipline within the last academic year. The participants ranged from new university teacher educators (less than one year) to experienced university teacher educators (more than 20 years). Each university teacher educator has taught professionally in a K–12 school setting in the particular discipline that defines each methods course. No participant had a degree or specialized training in technological use other than workshop or professional development experiences, technology-specific seminars, or content-area coursework as part of formal academic training.

5.2. Theoretical Framework

The group embraced an interpretivist theoretical perspective of constructivism with a constructionism and contextualism epistemology [20]. The purpose of the study was to describe individuals' perspectives, beliefs, and experiences of technology in methods courses, which fits within this research methodology framework. The sampling strategies were purposeful, and the data collection relied on individual contributions and narratives. Authors composed vignettes of current technology use in methods courses with the aim of analyzing each vignette for specific themes and perspectives in order to identify commonly held attitudes, practices, and beliefs. Trustworthiness was established through group communication, collaboration, and member checking, since the main knowledge producers were the participants.

The research questions for the group of teacher educators included:

1. What technologies do teacher educators use in methods courses?
2. Why does this group of teacher educators use specific technologies? Toward what outcomes?
3. How does this group of teacher educators imagine incorporating the TETCs and discipline-specific technologies into their methods courses in the future?

Specific data was collected by surveying the group of methods instructors both in-person and via email, collecting written vignette examples of the "what, why, and how" of technology use in each discipline, and examining official documents (i.e., syllabi, assignments) from each methods course to find technology use and explanations. The group of teacher educators conducted this study to evaluate the technologies currently employed in their courses, to delve into the reasoning behind this technology use, and to explain how this technology use aligns with the TETCs, as individuals and as a group.

6. Results

The following are the vignettes that were prepared by each methods instructor in the college of education's secondary education group. Vignettes were informed by survey data, syllabi, and course documents, and the aim of including these vignettes was to provide the reader with a picture of content-specific technology use in one program, focusing on the present, as well as on future ideas and possibilities for each methods program. Each vignette is organized to address the three research questions of the study: (1) an introduction, including pertinent disciplinary literature; (2) a survey of existing technological practices in the secondary methods courses; and (3) a discussion of using the TETCs to further preservice teacher experiences with technology in the classroom and in field placements.

6.1. Agricultural Education (AgEd)

Many technologies used in agricultural education are discipline-specific and therefore seem second nature, which only further necessitates teacher preparation programs to teach technology use with intention. Like most fields, other technology resources are emerging and could propel instructional strategies and field experiences for preservice teachers into a technical age that is ubiquitous for AgEd. Integration of and studies exploring technology in agricultural education have addressed the attitudes and beliefs of faculty [21] as well as the incorporation of technology into classrooms [22]. Studies addressing elements of technology practices by teacher education faculty and technology use or application have been lacking.

Interaction with various methods, for example, welding, machine repair and maintenance, and laboratory management are crucial in preparing future teachers. The Agricultural Education Lab features numerous machines in these fields, including Shielded Metal Arc Welding (SMAW), Gas Metal Arc Welding (GMAW), Tungsten Inert Gas Welding (TIG), Oxy-Acetylene Welding, and a plasma cutting table. The teacher educator uses the welding equipment to allow agricultural education preservice teachers opportunities to develop and practice skills in welding and evaluating weld quality, practice the repair and maintenance of machines, and develop strategies for managing student behaviors in an agricultural mechanics laboratory. Pate, Warnick, and Meyers [23] conducted a national survey to research the key welding competencies required for success as a beginning agriculture teacher. The most essential competencies that emerged focused on performance skills, technical knowledge, laboratory management skills, and disposition [23]. The equipment and instruction used to prepare teacher candidates as competent welders are essential.

Another universal resource in agricultural education, since its inception in 2007, is a record-keeping web application called the Agriculture Experience Tracker, or the AET [24]. The site boasts nearly 422,000 student users who have collectively recorded over 22 million "learning hours" and over $512 million in "financial experience value" related to work-based learning experiences [24]. The AET, as shown in Our Story [25], is a powerful tool for tracking data on student, teacher, program, and community levels by allowing K–12 high school students to record learning hours or financial data in relation to how their learning interacts with the local economy. Additionally, teachers can record their extended contract hours, and student-leaders can record goals and outcomes for local agricultural education programs. Using the website to prepare teachers permits candidates to track similar data concerning their experiences and familiarize them with the system for future use in their classrooms.

Literacy is incumbent upon all teachers in modern education, and agricultural educators must infuse the curriculum with a focus on intentional reading strategies, such as online resources, to prepare preservice teachers for this obligation. Still, in-service agriculture teachers often avoid instructional activities which seek to improve content reading practices. This evasion can be attributed to factors including self-doubt as a reading teacher, the sacrifice of content-specific instructional time, and the perceived insignificance of reading instruction as it applies to the content area [26]. Providing instruction and resources allow agricultural education preservice teachers, who may not otherwise be prepared for reading instruction, to teach content reading in agriculture. One such resource is Newsela, which allows users to select and assign readings from current events aligned to specific content (Newsela; https://newsela.com) (accessed on 16 Oct 2021). The distinguishing factor of Newsela is its ability to adapt the text to varying Lexile levels based on the readers' needs, as indicated by their performance on comprehension questions. The site also features digital tools for interactive reading and can provide preservice teachers with direction and assistance when planning literacy instructional techniques, no matter their content focus.

For teacher educators, video reflection coupled with peer feedback is a critical technique for shaping preservice teachers' future instructional techniques. A recent qualitative study noted a tendency for teachers to focus on their own performance in their video reflection annotations and not on student learning outcomes as a result of their instruction [27]. Reflection continues to be an essential skill for teachers throughout their careers, and using video reflection technology in the process focuses its effectiveness [28]. An operative tool for this process is Flipgrid (Flipgrid; https://info.flipgrid.com) (accessed on 16 October 2021), a web application allowing preservice teachers to participate in reflection by providing a platform for recording short instructional sets and sharing videos with a closed community of users.

In addition to a platform for sharing video content, an online learning management system (LMS) is often a component of preservice teacher programs. Canvas is the LMS used across campuses and offers benefits for diverse learners, including an environment for free discourse extending beyond the confines of the general class schedule and environment, opportunities for content-based digital networking, and the practice of routinely using a digital platform for teaching and learning, which is required of most K–12 teachers today (Canvas; https://www.instructure.com/canvas) (accessed on 16 October 2021).

As a teacher educator, preservice teacher data is both important and followed using a menu of assessments throughout the degree program, including GPA, Unit Plan Evaluation, midterm and final evaluation during student teaching, and the Educational

Teacher Performance Assessment (edTPA; https://www.edtpa.com/) (accessed on 16 October 2021). The technology used in preparing these preservice teachers is fundamental to promoting optimal performance on these assessments, and the teacher educator utilizes this technology first before sharing it with the preservice teachers.

In agricultural education, teacher educators and preservice teachers are able to interact with content-specific technologies by evaluating and predicting their use in future instruction (TETC 1). The variety of technologies used in teacher preparation gives preservice teachers the opportunity to analyze, evaluate, and even cultivate new information in a modern era. This contextualized experience afforded to preservice teachers allows them to select and explore content-specific technologies to use in the future while illuminating opportunities to practice using prominent technologies in the field (TETC 2). Utilizing emerging technologies to train future agriculture teachers opens more avenues for integrating disciplines and expanding learning experiences to a global level (TETC 8). Finally, when teacher educators embed technologies in teacher preparation practices, it prepares preservice teachers for the demands of troubleshooting and instills the character of grit required for immersion in progressive technology use in education (TETC 12).

6.2. Career and Technical Education (CTE)

Technical education methods are different from the other methods for secondary education programs provided at the university, and, as such, this vignette describes the process for arriving at these methods. There is an increasing need for CTE preservice teachers and teacher education programs [29–31]. The preservice teachers in the program rely on coursework from the community college to provide them with introductions to as well as the application of software and technologies utilized in industry. The preservice teachers, in addition to acquiring an associate degree at the college, take a blend of content courses from the university with the same instructor as their methods course, where one key objective is lowering barriers to technology use and anxiety about technology use [32]. These preservice teachers, being exposed to technologies before methods courses begin, are therefore in need of instruction on how to implement and experiment with technologies in everyday K–12 secondary technical education classrooms with regard to planning, instruction, and assessment [33]. The technical education program is divided into the following four categories: (A) communication; (B) manufacturing; (C) power, energy, and transportation; and (D) construction. Within each of the culminating university courses, the teacher educator guides the methods courses, beginning with how to utilize the learned concepts and technology in the secondary classroom.

During communication, preservice teachers take a series of courses in which they work with and learn the software. The preservice teachers work with AutoCAD, or computer-aided design, and then move into SolidWorks, where they work in the realm of 3D CAD. Once these courses are complete, the preservice teachers advance to working with Photoshop, InDesign, Excel, and Word. As part of the class, they utilize digital single-lens reflex cameras. They create promotional material for a course they will teach once in a student-teaching residency. The cameras become a technological avenue that captures preservice teacher interest while allowing for a greater understanding of the elements of design, the principles of design, and photo composition. The structure of the CTE program, championed by the teacher educator, aids preservice teachers as they obtain drafting software along with layout and publishing software, which allows for multiple avenues of application in K–12 secondary classrooms.

In manufacturing, the preservice teachers progress through two welding courses. They work with GMAW, gas tungsten arc welding (GTAW), and a computer numerical control (CNC) machining methods course. The machining methods course is a unique course, in that the teacher educator builds off of previous CAD experience and has the preservice teachers designing and working with the 3D printer, CNC router, laser, and plasma computer-aided manufacturing (CAM). The preservice teachers are then provided opportunities to design and create manufacturing projects geared toward K–12 secondary technical education. Most preservice teachers can use these projects as part of the units that they construct for methods classes, as well as for lessons to use during K–12 student-teaching residencies.

During power, energy, and transportation, preservice teachers progress through a series of three courses covering electronic circuits, electrical concepts, and digital electronics. They take courses in which they explore activities in flight, wind, solar, and programming. They become familiar with microcontrollers such as Arduino, used to program robots, and other applications that utilize controlled electronic constraints or conditions. Familiarity with the Vernier LabQuest and sensors (https://www.vernier.com/products/interfaces/labq) (accessed on 16 October 2021) allows preservice teachers to collect measurements on thrust and velocity with flight activities. They also use Vernier sensors for calculating load when using the structure tester to establish the most efficient structure, whether it be a bridge, a beam, a truss, or a tower. The methods course is then where they identify appropriate applications of the previous technologies and identify their uses within K–12 secondary classrooms. The teacher educator purposefully utilizes programming and the use of open-source software as an aid to those preservice teachers working with robotics. LabQuest projects have assisted in the design and limitations of projects, whether they focus on flight or another aspect in which a hypothesis must be structurally tested.

During program experiences in construction, preservice teachers identify and assemble small units of construction, dealing with foundations, residential wiring, framing, roofing, plumbing, finish, or cabinet work. They incorporate and use the labs so that they can build and test items such as the R-value for insulation, whether it be a wall, window, or roof section, utilizing the Vernier LabQuest sensors. During methods, the preservice teachers build instructional units that align with their residency placements. They are able to incorporate the technologies found in K–12 secondary classrooms into their daily instruction. The teacher educator provides repetition for the preservice teachers in several ways during methods. By reintroducing Vernier sensors and multiple software opportunities, the preservice teachers can work with multiple file types and programs to troubleshoot coding issues (e.g., CNC machines) and thus make the transition to using the resources in the K–12 classroom easier. The methods course also offers a few drone activities. In the future, the methods course could explore more fully how drones relate to mapping, and a focus on completing tasks autonomously could be beneficial.

The teacher educator faces challenges with teaching preservice teachers in these varied applications and these challenges primarily include funding for the software and hardware (TETC 1, 2, 3, 4). Additionally, a challenge for teacher educators is finding opportunities for preservice teachers to acquire the necessary experience in using the machines and software prevalent in K–12 schools. These opportunities are difficult to secure because of the cost of consumables for the machines that they need to utilize, in addition to the training needed to operate the equipment. The teacher educator should stay ahead of or equivalent to what is being utilized in K–12 school settings. Thus, a rationale for multiple software packages and equipment experiences is that teacher educators do not know where the preservice teachers will eventually be employed (TETC 5). A CTE teacher educator commonly struggles to completely prepare preservice teachers for the array of technologies that they might encounter within the K–12 secondary classroom. However, since the teacher educator provides varied opportunities to design and troubleshoot, preservice teachers should be adequately prepared for technology prospects and challenges as they arise in the future (TETC 12).

6.3. Mathematics Education (ME)

Mathematics teacher educators do not always teach preservice teachers how to use generic technology pieces (SmartBoards, spreadsheets, etc.), as schools have stand-alone technology courses for that purpose, or preservice teachers are already comfortable with these technologies [34]. At this particular university, there is an expectation by the teacher educator that preservice teachers come to the mathematics methods courses with competence in generic technologies. There are some unique means to bring focus on mathematical concepts, teacher educators' use of technology in areas such as statistics [35], online environments [36], teacher education methods course contexts, and applications of technology [37]. For mathematics teacher educators, the goal is to provide technology use and support within the framework of mathematics content and teaching strategies while providing a variety of experiences and experiments for preservice teachers in their mathematics methods coursework.

Specific, discipline-based technologies are focused on in methods courses at this university. For example, the mathematics teacher educator utilizes robotics in the sense of positional/orientational geometry. Preservice teachers answer questions such as: (1) "how many degrees can the robot turn to the right to make a square and end up in the same orientation?"; (2) "how can the robot travel a regular pentagon, hexagon, octagon, or n-gon?"; and (3) "what is the largest number of sided regular figure that the robot can make?".

The Hour of Code (and 3D printing using OnShape) is another technology that several content areas might teach as part of methods. However, the mathematics teacher educator can embrace the Hour of Code to teach new programming languages and show preservice teachers how central mathematics is for operating in a STEM world. The logic relationships in coding languages (e.g., repeat, if/then, not) are also important concepts in mathematics, and the connections are important for the teacher educator to make with the preservice teachers. Using 3D printing and CAD software to create shapes are other real-world applications of mathematics that teacher educators need to learn to assist preservice teachers in experiencing concepts through creation. Other technology tools used by mathematics teacher educators can include:

1. MURSION, which is used for modeling small practice teaching experiences focused on mathematics concepts or other disciplines (https://www.mursion.com/) (accessed on 16 October 2021);
2. Spreadsheet software, which is useful for explaining large data sets and manipulating the data with formulas. This data can also be transferred to other graphing programs;
3. Vernier probes and sensors which collect and process data from experiments to show graphical mathematical ideas through experiences (e.g., Walk the Graph motion detector)
4. GPS, which is a global positioning system to consider distance, how one identifies when one is on a sphere, and how many satellites are needed to find a position.

Mathematics teacher educators have many options for discipline-specific technologies to utilize for best practice. These include geometrical microworlds such as Geometer's Sketchpad (GSP, http://www.keycurriculum.com/) (accessed on 16 October 2021) and LOGO (a programming language), which are useful for considering conceptual questions, such as "what is a proof?" and "how can I construct and generalize 2D shapes?" [38,39]. Seeing these same mathematical ideas in a variety of technologies (LOGO is a positional geometry as well) identifies mathematical concepts as overarching, as well as answering the eternal question of "when am I ever going to use this stuff?". Geogebra (https://www.geogebra.org/?lang=en) (accessed on 16 October 2021) is an internet-based freeware that can be used to explore these same questions as well as other ideas from algebra and other secondary mathematics content. Preservice teachers should be familiar with a variety of these tools, as schools have varying types of technologies available. Desmos (https://www.desmos.com/) (accessed on 16 October 2021), an internet-based graphing calculator freeware tool, and hand-held graphing calculators are standard tools that most preservice teachers have experienced using while learning mathematics. Desmos includes applications that involve conceptual mathematics ideas. Mathematics teacher educators use these tools to strengthen conceptualizations in mathematics and in teaching mathematics. It is beyond showing what button to push to get an "answer", into exploring what questions are best posed to prompt K–12 secondary students to think about mathematical concepts [40].

Technology use by mathematics teacher educators allows for preservice teachers' opportunities to discern visual representations that aid future K–12 students in developing understanding [41]. These representations in mathematics and in STEM fields to express complex ideas in meaningful ways offer teacher educators access to powerful preservice teacher supports. K–12 secondary students should have mathematics teachers who can scaffold experiences to provide ease in accessing mathematical ideas, even though the ideas are expressed in different software (e.g., MatLab, Mathematica, MAPLE) at the university level. Cuban [42] compared technology use to a chalkboard and stated that a chalkboard does not necessarily result in deep conceptual learning. Using technology purposefully can allow preservice teachers to control their explorations at their own entry point and progress to meaningful representations. However, Erlwanger [43] showcased the dilemma of engaging in computer-based explorations without a teacher to guide or mediate learning with the technology. This flawed approach of exploration without intent can lead a preservice teacher or K–12 student to develop mathematical misconceptions.

For credentialing, the Specialized Professional Association (SPA) in mathematics education requires preservice teachers to know a variety of content-specific technologies for "national recognition" program accreditation. The National Council of Teachers of Mathematics (NCTM) identifies technology as a critical component of teacher preparation, and all of the standards prescribed for preservice teachers would also meet the TETC Standards for Teacher Educators. NCTM requires content-specific technologies as well as more generic pieces to be a central focus of both learning mathematics and learning to teach mathematics. NCTM requires preservice teachers to learn to use appropriate technologies in their mathematics content coursework. So, preservice teachers are to (1) learn with the technology in mathematics content coursework, (2) utilize specific teaching strategies through a mathematics methods teacher educator modeling specific teaching strategies, and (3) require technology use as a teaching tool for mathematics in 6–12 settings.

Mathematics educators must stay current with technologies to help teachers use best practices in teaching, and key questions about this process should be addressed: (1) "how does one stay current with technologies with the limited amounts of time available?"; (2) "who is to help keep the mathematics teacher educator current with access and information about new technologies?"; and (3) "is this the responsibility of the teacher education technology faculty at the university, or elsewhere?". In answering these questions, mathematics teacher educators must consider the state of the education faculty and support systems available at their university. Teacher educators can work across disciplines and learn from their engineering and other STEM colleagues. Many mathematics conferences and workshops are also excellent ways to see new technologies and determine what to learn. Attending national or local workshops designed to teach a specific new technology is also useful. Working with teacher education technology specialists, who are also faculty, is dependent on the interest of teacher educators. The dilemma becomes how interested are teacher educators and how much time do they have to spend on these collaborations?

Many of the challenges faced by teacher educators in using technology are the access and affordability of the technologies. Early in the 1990s, the university had to work to keep up with some school districts' technology resources. Now, this disparity has leveled, and the emphasis is placed on developing deeper conceptual understandings rather than providing mathematical problems used as nothing more than a technological worksheet. As more useful technologies come along, abandoning less-useful technology becomes critical. However, it is an important question to consider: what mathematics concepts are being taught here, and are they critical and worth the time in a time-limited mathematics methods course?

In mathematics education, teacher educators and preservice teachers will be able to evaluate technologies to use in specific mathematics disciplines (such as software applications oriented towards geometry, algebra, calculus, etc.) with a focus on specific content but using shared skills and cross-disciplinary thinking (TETC 1; TETC 2). Within mathematics, the emphasis on the achievement gap as well as national pressure through the Common Core standards requires a systematic approach to differentiated instruction that scaffolds learning and technology onto each concept in order to improve mathematics education on a national (and local) level. This can be facilitated through the use of specific technologies to help with differentiation, such as Pearson's new adaptive tutoring calculus app, AIDA, and through careful consideration of age and educational-appropriate technologies to facilitate mathematics for all learners (TETC 5). Finally, like the other content areas, teacher educators must prepare preservice teachers for the evaluation and trouble-shooting of technology as a way to provide skills that will adapt over time and be utilized as new technologies are developed for mathematics education. Educating preservice teachers to consume and be critical of new technologies will allow for a career-long orientation towards increasing technological knowledge and know-how for program graduates (TETC 12).

6.4. Science Education (SE)

Within the realm of science education, there are a myriad of hardware and software choices that enable preservice teacher educators to demonstrate their technological competence, as defined by the TETCs, while meeting the content and pedagogical knowledge requirements specified by the National Science Teacher Association's [2] standards for teacher preparation. Many of these technologies are cross-curricular in nature and have the potential for collaboration with other disciplines within the secondary school system (e.g., mathematics, CTE, social studies) [44–49]. Many of the technologies used in the science methods classroom are not implemented as standalone components; rather, they are used together with other technologies. The following are five different technology integrations for the secondary science methods classroom utilized by the science methods teacher educators.

The first technology described utilizes both hardware and software in a classroom and in a field setting. The ubiquitous nature of global information systems (GIS), coupled with global position satellite (GPS) hardware, enables preservice teachers to bring real-world problems into the classroom. To begin using these technologies in the preservice classroom, a field trip is designed by the teacher educators for the future science teachers. The field trip is fully supported by an ArcGIS (2019) story map created by the teacher educators using an inexpensive GPS and free ArcGIS mapping software. The GPS is used to collect location data at specific sites, where measurements and observations are made during the field trip. In addition to location data, pictures and videos are taken at these locations to further support preservice teachers as they complete each task in the field. These components (coordinates, photos/videos) are uploaded into an ArcGIS story map building tool. This tool enables one to build a story using GIS mapping technology. Preservice teachers use the story map to complete tasks at specific GPS locations. These tasks may include collecting data with specific tools (e.g., temperature, wind speed, humidity, slope, water pH, etc.) or making observations (e.g., plant identification, animal behavior, geologic phenomena, etc.). Preservice teachers enter the data into forms downloaded directly from the story map and can upload them once they return to the classroom for analysis. Once preservice teachers have experienced the story map for themselves, they can create their own story maps to supplement the lesson plans designed during the methods semester.

A second technology—usually referred to as probeware—that can easily be utilized in the field for story map data collection is more typically found in the classroom and laboratory. Digital data collection devices such as Vernier or PASCO probes have a multitude of capabilities and analytic tools that are content-specific. These data collection devices enable preservice teachers to collect data for answering questions in all areas of science and engineering. These probes are designed with science education in mind, are user-friendly, robust, and, when coupled with the generous site license for the analysis software, become an excellent tool for making science tangible. In the methods classroom, preservice teachers develop testable questions and use Vernier probes to collect data to answer their questions. Developing a testable question is a difficult task for teacher educators and preservice teachers alike, and teacher educators sometimes struggle to provide opportunities to enhance this skill for preservice teachers. Fully developing experimental designs that are supported by these technologies prepare teacher educators to challenge their preservice teachers via science and engineering practices.

In the classroom and at home, interactive technology platforms such as BioInteractive (https://www.hhmi.org/biointeractive) (accessed on 28 October 2021), PhET (https://phet.colorado.edu/) (accessed on 28 October 2021), DataCorral (https://datacorral.uwyo.edu/) (accessed on 28 October 2021), and NetLogo (https://ccl.northwestern.edu/netlogo/) (accessed on 28 October 2021) bring science to life and are essential for teacher educators to showcase modeling in a scientific sense. These simulations invite participants to wrestle with concepts that are abstract and perhaps difficult to implement in the laboratory, due to limited time and resources. Preservice teachers manipulate variables, design experiments, and collect data from web-enabled devices (e.g., HTML, flash-capable devices), and the teacher educator can be as engaged or non-engaged with these steps as needed. The simulations are extensions for content knowledge acquisition and review as preservice science teachers prepare for demonstrating their content knowledge on national exams such as PRAXIS II, and teacher educator emphasis on modeling software is a crucial piece of the puzzle. These experiences further enable differentiation strategies to be developed and later used by the preservice teachers in their practicum and residency classrooms as homework, independent practice, or in learning centers.

Teacher educators can integrate computer science, mathematics, CTE, and science when using robotics in the secondary science methods classroom, such as Lego Mindstorm software and Lego robotics (https://www.lego.com/en-us/mindstorms) (accessed on 28 October 2021). Beginning with a Lego Mindstorms robot and software, teacher educators lead preservice teachers as they work through the engineering design/test/redesign process to build a robot that is autonomous or can be run with a Bluetooth-enabled device. Programming can be taught through tasks such as making the robot go through a maze or using light or ultrasonic sensors to navigate an obstacle course. The programming interface is simple and it is easy for preservice teachers to develop a robot that is capable within a few short hours. Using a problem-based learning model, preservice teachers solve problems, learn basic coding, and engage in the engineering design process. Again, teacher educators model the process of integration, differentiation, and problem-solving in the preservice classroom, while leading preservice teachers through technological experiences.

Finally, utilizing microcontrollers such as Micro:bit (https://microbit.org/) (accessed on 28 October 2021), Raspberry Pi (https://www.raspberrypi.org/) (accessed on 28 October 2021), and Arduino (https://www.arduino.cc) (accessed on 28 October 2021) can assist teacher educators with synthesizing and integrating science concepts and computer science. As a specific example, preservice teachers showcase the integration of technology use with science content (e.g., Micro:bit) by including it in lessons directly from NGSS—DCI, CCC, and SEP, including (1) DNA (HS-LS1-1; HS-LS1-6; HS-LS3-1; HS-LS3-2; HS-LS4-1); (2) Structure and Function; (3) Earth's Systems (MS-ESS2-6); (4) Weather and Climate; (5) Waves and their Applications in Technologies for Information Transfer (MS-PS4-1; HS-PS4-2); and (6) Waves and Electromagnetic Radiation. Thus, teacher educators can once again lead preservice teachers into utilizing cutting-edge technology to reinforce scientific concepts, skills, and themes.

The above examples enable teacher educators to assist preservice teachers as they develop skills in disciplinary core ideas, crosscutting concepts, and science and engineering practices, fully implementing the three-dimensional learning described in the Next Generation Science standards [2]. Within the TETC framework, the above examples demonstrate how teacher educators, as well as preservice teachers, are designing instructions, incorporating instructional pedagogies, utilizing online tools, and developing knowledge, skills, and attitudes to successfully utilize technology in their classrooms and future classrooms [3]. If teacher educators are going to meet the competencies set by the TETCs and the standards set by the NSTA, they must have practical experience with technology in their training.

For science education, teacher educators and preservice teachers are able to interact with content-specific technologies (for each science field/content area) by evaluating possibilities and working to include them in future instructional settings in both science lecture and lab scenarios (TETC 1). This contextualized experience in the sciences afforded to preservice teachers allows them to select and explore content-specific technologies to use in the future, while illuminating opportunities to practice using prominent technologies in the field (TETC 2). Utilizing emerging technologies to train future science teachers opens more avenues for integrating the various science disciplines and expanding learning experiences to a global level (TETC 8). Finally, when teacher educators embed science-specific technologies in teacher preparation practices, it prepares preservice teachers for the demands of troubleshooting and instills the character of grit required for immersion in progressive technology use in education. Moreover, the pairing of discussions of science and research ethics with technology ethics can be incorporated into science teacher education curricula. Pairing the science and technology conversations around best practices in research methods and participant protections/safety in lab settings can complement technology discussions around the same themes while expanding to include digital privacy and ethics (TETC 9).

6.5. Social Studies Education (SSE)

In his landmark article, Martorella [50] claimed that technology in social studies was a "sleeping giant" that had yet to be awakened. Exploring the early years of the internet and web-based technologies in schools, the article argued for the rethinking and reshaping of social studies in a computerized world. Accordingly, the outlook was hopeful, and there was the potential for inquiry-based social studies work and research using computers and the internet. Subsequent articles and follow-up studies to his initial call for waking the "giant" show growing interest but also a mixed track record in the field [51–53]. Other articles show various technologies and how they could impact schools, social studies classrooms, and teacher education programs [53–56].

The National Council for the Social Studies (NCSS) has officially called for further technological and pedagogical work in teacher education with special emphasis on the information and communication technology (ICT) revolution, as mobile devices and access to information become pervasive [57]. In Standard 2 of the core competencies for social studies teacher education, the NCSS highlights necessary technology skills, such as, "candidates plan learning sequences that leverage social studies knowledge and literacies, technology, and theory and research to support the civic competence of learners" [58].

Within this secondary program and in the methods coursework, there are a few examples of how technology can be used and modeled in order to support the development of the TETCs while linking directly to the NCSS teacher educator standards and necessities for advancing the social studies field. GIS, powerful datasets and real-time statistical analysis software, digital and multimedia archives, and digital interactive mapping tools have been imperative for developing technological aptitudes for social studies teachers that move them away from the passive overuse of presentation technologies and media.

One example is the use of state-wide, digital mapping, paired with GIS, that contains interactive geographical data that can be manipulated in real-time. GIS has been used in social studies and teacher education classrooms to explore geography and spatial literacy to link with historical trends, narratives, and content to provide the active corroboration of changing political, social, and industrial trends [59,60]. As mentioned in the science methods vignette, ArcGIS is a powerful tool that allows for the discovery of energy deposits, oil, and gas [61]. The Wyoming Atlas Project is an extension of ArcGIS and allows for the localized exploration of key geographical and geological information [62]. Paired with historical sources and references, methods preservice teachers took part in an inquiry-based exercise looking at ghost towns and how energy production has led to a series of boom-and-bust cycles around towns in Wyoming. Teacher educators in social studies can then use physical maps to mark key energy resource locations, boom-and-bust cycles throughout history, and how to determine population changes, industrial growth, and gross domestic product changes at state and national levels due to energy production cycles.

Another way to use datasets within an interactive framework is through United Nations (UN) statistic databases and the Gapminder software developed by the late Hans Rosling and his team [63]. Using a variety of variables (life expectancy, education level, gender equity scores, etc.), UN statistics are tracked through an animated graph that changes as the years advance. The graph is fully manipulative, and you can start or move from any year to the next or in large chunks. Key world events such as WWII, the economic explosion in China in the 1970s, and the influenza outbreak of 1918 (linked with COVID-19) can be seen in distinctive and graphical ways never before experienced. Teacher educators could devise planning activities for preservice teachers to track American economic prosperity through a variety of variables and could link the expansion of the middle class to key historical and social factors (i.e., college attendance rates, industrial production levels). This use of UN statistical databases and interactive and engaging graphing allows for social studies information to be viewed along a changing temporal plane, opening spaces for new and more dynamic inquiry-based questions that can be used by K–12 secondary students and social studies teachers.

These two examples show just a couple of ways in which SSE instruction can include technology in a robust fashion. There are newly developed and cross-curricular technological opportunities awaiting preservice social studies teachers and teacher educators. Within the methods coursework, the challenges have been structural and dispositional. The many social studies methods utilized in this program showcase that technology has an important place in the work, due to the value and access it provides. However, few social studies teacher educators take steps to fully integrate technology on a daily basis, as it becomes something done on a "special day" with preservice teachers in residency, or it becomes used to reify social studies lectures, as was feared by [52]. These structural concerns, such as the professional development and knowledge of technological advancement and operation, along with barriers in schools when they teach, provide challenges to teacher educators interested in the TETC framework and the comprehensive integration of technology into their methods courses.

With the recent publication of the TETCs, social studies teacher educators must emphasize technology's possibilities and uses to better understand how its incorporation can influence the future of the field. In this context, teacher education is the space for integrating social studies-specific technologies, while nurturing the dispositions and attitudes of preservice teachers, so that technology is an important part of the process of professionalization and teacher education pedagogy, as emphasized in TETC 3. The inclusion of technology in the SSE program reflects this uneven nature of incorporating technology into the field and opens questions about how the TETCs may ultimately influence the next generations of preservice social studies teachers. At the heart of the field is the balance of understanding and usage of technology. Manfra [52] posits a key point in the integration and understanding of technology in social studies and asks a powerful question of how we think of using technology in social studies programs.

It is important, then, for social studies educators to reconsider the metaphor of the sleeping giant and whether the myriad applications of technology in social studies have found a conceptual home. Perhaps the sleeping giant is really pedagogical in nature—not technological. Has technology simply reified the signature pedagogy of the lecture or chalk talk (now on a SmartBoard) or has it moved us to more democratic, reflective, and inquiry-oriented forms of instruction? (p. 6).

SSE teacher educators need to focus on avoiding reification and lecture/presentation-model uses of technology and push further to include active, inquiry-based approaches and media literacy experiences, all within the context of democratic values and practices. Within the TETC framework, competencies such as TETC 1, utilizing content-specific technologies, TETC 8, global connections, TETC 9, ethical and social responsibilities of using technologies, and TETC 10, advocacy for using and developing technologies for education, allow for truly powerful social studies teaching and learning that avoids the reification of the chalk and talk approach.

The TETCs show the various layers into which technology can be folded by teacher educators into their courses and the key elements of successful technology integration. In the future, newer and more powerful ICTs, for example, new and widely available technologies, will allow teacher educators and preservice teachers to, for example, explore family histories and migration (through DNA services), interact in philosophical conversations with artificially intelligent agents to enhance moral judgment [64], or explore AR/VR environments, such as a mapping of the French caves to explore soldiers' experiences in World War I [65]. How teacher educators begin to fold these ideas into methods coursework and teacher education programs as a whole can link the social studies work in the classroom with the aims of national organizations and the TETCs. However, these experiences must be done holistically and with active and inquiry-based approaches in social studies. Waking Martorella's "giant" has been slow but steady, and the ubiquity of ICTs and their unchallenged ability to alter the social structures of human beings means that these technologies can irrefutably alter social studies. Dispositions and structural needs are paramount to the holistic integration of technology into SSE classrooms.

7. Findings

Table 1 summarizes the technologies used, the brief purpose of the technology, how the technologies are used, the TETC attached to the technology by the teacher educator, and the PTSB (state-level teaching standard) or SPA standard addressed in each of the methods courses. The technologies used in these courses were instructor-selected based on current trends in the field.

Table 1. The Uses of Pedagogic Technology by Content Area.

Content Area	Technology	Purpose (Why)	Use (How)	TETC	Standards
Agriculture Education	AET	Track economic goals and outcomes	Familiarize for use in classrooms	1; 2	PTSB 4, 5.a
	FlipGrid	Video recording	Reflect on teaching	8; 12	
	LMS—Canvas	Utilized by K–12 schools	Digital platform for teaching	1; 2	
	Newsela	Adapts to reading level	Content reading	1; 2	
	Welding	Repair and maintenance	Develop and practice skills	1; 2	
Career Technical Education	Software: AutoCAD, SolidWorks	Design, visual representations allowing for multiple drawing types	Constraints for ensuring proper design and material before manufacturing	1.a–c; 2.a–d; 3.c; 4.c–d; 5.a	PTSB 1; 2; 3; 4; 5.d, f, h
	PhotoShop InDesign	Create visual graphics and text	Non-verbal communication, develop ability to analyze elements of composition	5.c–d; 6.a–c; 8.b; 10.c; 12.a–b	
	Excel, Word, Google	Pivot tables, graphs, charts, forms, team drive	Create assessments of learning, graph student outcomes, group work		
	Digital cameras	Capture images and shapes	Develop perspective		
	Plasma CAM Laser 3D printing	Cut or construct shapes and products	Manufacture usable goods		
	Vernier LabQuest; Sensors	Collect data	Create graphs supporting hypotheses		
Mathematics Education	3D Printing	Construction of 3D shapes	Modeling conic sections	1.a–c; 2.a–d	NCTM
	Calculators, DESMOS	Tools for graphing	Features, uses in teaching; function representation development	3.a–c; 5.a–d	1.A.1.1–4
	Coding/LOGO	Non-Euclidean programming	Lessons in working with angles	6.a–c	A.2.1–5; A.3.1–10
	Geogebra	Connections to algebra	Evaluation for teaching		A.4.1–5

Table 1. *Cont.*

Content Area	Technology	Purpose (Why)	Use (How)	TETC	Standards
	Geometer's Sketchpad	Connections to algebra, trigonometry	Introduction to using an electronic tool		A.5.1–3; A.6.1–4
	GPS	Triangulation	Location, irregularly shaped area approximation		2.a–f; 3.b–g
	Robotics	Develop regular shape formulas based on interior/exterior angles	Develop math concepts through investigation and problem solving		4.e; 5.b
Science Education	GPS	Precision and accuracy of data	Advantages of technology (e.g., compare GPS to traditional map reading); spatial reasoning	1.a–c; 2.a–d; 3.a–c; 12.a–d	NSTA 1; 2; 3; 5; 6
	Probeware	Measure "difficult-to-capture" data; continuous data collection	Show patterns over time	1.a–c; 2.a–d; 3.a–c; 12.a–d	1; 2; 3; 4; 5; 6
	Interactive technology platforms (e.g., NetLogo, Data Corral)	Model objects, systems, etc., that are often impractical to use; coding practice	Working and creating models; collecting data; analyzing data; computer science applications	1.a–c; 2.a–d; 3.a–c; 4.a–d	1; 2; 3; 5; 6
	Robotics	System interactions; form and function; coding practice; development and test cycle	Problem-solving; engineering process; computer science applications	1.a–c; 2.a–d; 3.a–c	1; 2; 3; 5; 6
	Microcontrollers (e.g., Micro:bit)	System interactions; form and function; coding practice; development and test cycle	Problem-solving; engineering process; computer science applications	1.a–c; 2.a–d; 3.a–c; 12.a–d	1; 2; 3; 5; 6
Social Studies Education	Datasets	Census, UN stats	Population and demographics changes	1.a–c; 2.a–d	NCSS 1.a; 2.b; 2.e
	GPS	Geography/spatial sciences	Mapping, meaning and space	4.a–d; 5.a–d	5a
	Spreadsheets	Economics, public data organization	Exploring macroeconomics	6.a–c; 8.a–c	
	Mountain West Atlas	Geography/spatial sciences	Mapping, meaning in space, local/place-based study		

8. Limitations

This study was intended to show technology use in secondary methods coursework and to critically link it to the TETCs. There were several limitations in this study. First, in a methods program, the authors continually confer and share experiences with technology, both general-purpose and content-related, and share key dispositions and attitudes towards technology use as teacher education faculty. This limitation leaves gaps in the ability to study teacher educators who may hold differing opinions or disagree with the technological norms of this program. Second, in this study, the authors examined a one-year time frame, which included a single year of syllabi, technology expectations and usage, and access to content-specific technologies. The authors readily admit that, over time, the depth and breadth of technology use changes in each content area, and is largely dependent on teacher educator professional development, as well as unique college of education aims and changes to national standards or expectations for technology use in specific content areas. Finally, the artifacts and vignettes were solely based on teacher educator perspectives and experiences. There are no artifacts or data sets from preservice teachers, administrators, outside course evaluators, local stakeholders, or statewide stakeholders. This limits the focus of the article to the perspectives of one university's teacher education program, which may not reflect the perceptions or attitudes of other groups or stakeholders within—or linked to—these specific teacher education programs.

There are key institutional and programmatic gaps that have been identified and need to be addressed. Major challenges include developing meaningful professional development for teacher educators and collecting data on those endeavors, better understanding practitioner as well as teacher-educator knowledge of educational technology, and beginning a research-based approach to understanding and adopting the TETCs in a holistic manner.

9. Discussion and Conclusions

The vignettes and technology chart show a vast array of content/discipline-specific technologies being used in methods courses at the university. Each teacher educator has built technology into their teacher education coursework with an eye towards future technologies and understanding these technologies, for both preservice teachers and themselves in their program work. As teacher educators, the authors found important commonalities among their work in the methods courses studied for this article. Four key themes emerged from the vignettes and link back to the research questions.

(1) Teacher educators are using domain-specific technologies in their programs and make important distinctions between general education technologies, and discipline-specific technologies (Research Question #1);
(2) Methods instructors must know, understand, and use the technology and pedagogical skills that preservice teachers are taught and are expected to use in their classrooms (Research Question #2);
(3) Methods instructors are meta-experts and are expected to discover and maintain technological competencies through workshops, conferences, disciplined study, and training, just like the K–12 teachers are required to do in their schools (Research Question #1);
(4) Content-specific conversations, often with content experts, impact the understanding and use of technology in teacher education classrooms (Research Question #2);
(5) Regarding the TETCs (Research Question #3), these themes show important attributes of technology use by teacher educators, as well as key gaps. The following examples are given to illustrate some current areas of alignment with the TETCs, as well as spaces for improvement in this methods program:
    (a) For TETC (1), this study shows that teacher educators are in a constant, iterative evaluation process of technology use in teacher education programs. The teacher educators felt that the technologies demonstrated in this study were implemented to align with the content and showed preservice teachers how to utilize technology in this way;
    (b) For TETC (2), there was less emphasis in this study. Although preservice teachers saw the modeling of technology integration into content applications and were able to use and experiment with technologies in these scenarios, there was no close alignment with preservice teacher evaluation skills with regard to finding, familiarizing, and incorporating technology into their own work. Often, it was a top-down approach, with teacher educators sharing and modeling key technologies in the field without necessarily encouraging student evaluative processes;
    (c) Regarding TETC (10), all of the teacher educators in this program sought out professional development for technology usage in the classroom. Among the teacher educators contributing to this article, there were various forms of professional training and development for each teacher educator, including conferences, colleagues, official professional development in the college of education, and personal research. However, the knowledge of content-based technologies that were the focus of this article was typically self-constructed and found through seeking out technology professional development specific to the teacher educator's content area, not through linked professional development with a specific institution or the college of education.
    (d) Finally, for TETC (11), there was a consensus among teacher educators in this program that providing preservice teachers with engagement and connections to technology organizations, collaborating with others, and understanding technology demands in local districts and at the state level contributed to

encouraging positive dispositions and leadership regarding the use of technology in the content area. TETC (11) provides one of the more powerful spaces for encouraging long-term, consistent personal development towards the integration of content-specific technologies in the preservice teacher's field.

The program studied in this article has many positives when linked to the TETCs, as well as to the literature on technology in teacher education. Teacher educator dispositions toward using technology are incredibly positive and supportive, and this has led to an energy within the program that is collegial and constructive. As positive dispositions about technology are key to successful integration [7], this is a solid foundation for the secondary program to build upon. This positive relationship with technology in the content area is also supported by academic freedom structures and important differences in the technology being used. Although teacher educators work every year to compare syllabi and classroom approaches, the teacher education faculty uses and integrates technology in different and nuanced ways throughout the program [18]. While this allows for unique approaches, the teacher educators in this program recognize the need for a more systematic and holistic reform approach, represented by the TETCs, to promote technology integration. Finally, for teacher educators, the commitment to discipline-specific technology and content knowledge is large and outside the scope of keeping up with evolving, discipline-specific knowledge, often requiring intense personal commitment to learning/harnessing new technologies, as well as to professional development in each content domain that supports and complements technology incorporation.

Key questions from the authors are grounded in how knowledge and dispositions are gained and maintained for teacher educators and exploring where this knowledge comes from. Authors viewed their personal knowledge as self-constructed, consisting of stumbling upon content-specific technologies through conference attendance, the literature, engagement with colleagues, and other outside influences. Some more formal structures, such as instructional technology departments, were not viewed as contributory in this process, and their influence in teacher educator technological knowledge was viewed as minimal.

From these realizations, important questions emerge for teacher educators and program leaders to consider in future research studies as well as in how these teacher educators construct their methods classes in the future. For example:

(1) How do we gain and sustain technological knowledge?
(2) How do we meld technology and content expertise through continued study and professional development for teacher educators?
(3) What do teacher educator evaluations show about teacher educator knowledge and the use of technology in university classrooms?
(4) What do mentor teacher and student teaching evaluations show about passing on knowledge on the use of technology to preservice teachers in K–12 classrooms?

The findings in this article suggest that there must be a "two-way street" of knowledge contribution to better incorporate technology into teacher education programs. Work among teacher educators and preservice teachers must be constructive and co-created, encouraging preservice knowledge and expertise to guide the exploration and experimentation processes for finding and integrating content-specific technologies. Secondly, there is a "two-way street" between technology experts and content experts in teacher education programs. Since educational technology experts are indeed invested in teacher educators using TETCs and learning the world of technology, then technology experts might want to examine and learn discipline-specific content for the preservice and K–12 classrooms that these technologies serve.

As a group, with this initial baseline analysis of what technology incorporation has been occurring, we are revisiting the conversation on a semester-by-semester basis about what technologies are being used and how the programs/courses can be better aligned to the TETCs. Sharing this work was a vulnerable and difficult process, as showing what was "being done" and how the authors hoped to improve upon it will hopefully inspire others to take up the challenge. For teacher educators, a greater understanding of content-specific technology needs, and an understanding of content by technology experts, will allow more robust dialogue across fields of education and will lead to a more holistic view of the TETC recommendations, as well as the desire of teacher educators to more effectively incorporate the concepts and ideas in the TETC framework into their secondary methods coursework.

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