Schmidt-Crawford, D. A, Foulger, T. S., Graziano, K. J., & Slykhuis, D.A. (2019). Research methods for the people, by the people, of the people: Using a highly collaborative, multimethod approach to promote change. *Contemporary Issues in Technology and Teacher Education, 19*(2), 240-255.

Research Methods for the People, by the People, of the People: Using a Highly Collaborative, Multimethod Approach to Promote Change

Denise A. Schmidt-Crawford
Iowa State University

Teresa S. Foulger
Arizona State University

Kevin J. Graziano
Nevada State College

David A. Slykhuis
University of Northern Colorado

This article highlights the highly collaborative, multimethod research approach used to develop the Teacher Educator Technology Competencies (TETCs): a specific list of knowledge, skills, and attitudes, developed with input from many teacher educators in the field, to help guide the professional development of teacher educators who strive to be more competent in the integration of technology. The purpose of this article is to describe and critique the sequence of three different collaborative research approaches (crowdsourcing, Delphi, and public comment) used by the TETC research team to gather critical opinions and input from a variety of stakeholders. Researchers who desire large-scale adoption of their research outcomes may consider the multimethod approach described in this article to be useful.

The theory and practice of preparing teacher candidates to teach with technology is inconsistent at best and ineffective at worst (Angeli & Valanides, 2009; Ertmer & Ottenbreit-Leftwich, 2010; Tondeur, Roblin, van Braak, Fisser, & Voogt, 2013). Some researchers have noted that the quantity and quality of technology experiences that teacher candidates encounter during their preparation programs influence their adoption of technology (Agyei & Voogt, 2011; Tondeur et al., 2012), while others have identified a gap between what teacher candidates are taught in preparation courses and how PK–12 teachers are actually using technology in classrooms (Ottenbreit-Leftwich, Glazewski, Newby, & Ertmer, 2010; Tondeur et al., 2012).

To address this gap, the ways teacher candidates are being prepared to integrate technology within the context of their preparation programs must be continually examined. Those who are preparing teacher candidates — teacher educators — must begin to examine and reflect on their own practices to determine whether they are, indeed, designing and modeling instructional opportunities that are preparing teacher candidates to use technology effectively in PK–12 classrooms.

The U.S. Department of Education (2017) has highlighted this concern, as well, and has called for teacher certification programs to devise methods that address a technology integration curriculum in a program-deep, program-wide manner. The challenge, then, becomes determining what technology knowledge and skills *all* teacher educators would need in order to design high-quality technology experiences for teacher candidates in their courses.

With a goal of building consensus in the field of teacher education, our research team embarked on an 18-month journey to bring focus and intentionality to efforts that prepare teacher candidates to use technology for teaching and learning. This research process solicited ideas from national and international experts on technology competencies that all teacher educators should use and were presented to the field for further comment and refinement all while being guided by an expert review panel.

The Teacher Educator Technology Competencies (TETCs) were developed using a unique consensus-building and highly collaborative research methodology. Specific results from this study are described in detail in Foulger, Graziano, Schmidt-Crawford, and Slykhuis (2017; see also http://site.aace.org/tetc/). The purpose of this article is to focus on and provide more detail around the three distinct collaborative research approaches (crowdsourcing, Delphi, and public comment) used to develop the TETCs.

The development of the TETCs was motivated by a call from the 2017 National Education Technology Plan authored by the U.S. Department of Education (2017), Office of Educational Technology, which recommended that teacher preparation programs "develop a common set of technology competency expectations for university professors and candidates exiting teacher preparation programs for teaching in technologically enabled schools and postsecondary education institutions" (p. 40).

The 2017 National Education Technology Plan purposefully shifted the idea of technology integration from a PK–12 focus of the prior plan to one that included commitment from every educational level, PK–20 (U.S. Department of Education, 2017). Specifically, the plan called for teacher preparation institutions to assure their graduates know that "effective use of technology is not an optional add-on or a skill that [they] can simply … pick up once they get into the classroom" (p. 32).

If all teacher preparation programs, in the United States and around the world, are charged with the need to prepare teacher candidates to use technology in powerful ways, then *all* teacher educators who are responsible for preparing these candidates must establish a curriculum for teaching with technology, serve as role models for using technology in teaching, and provide support to teacher candidates for developing their ability to teach with technology (Borthwick & Hansen, 2017; Goktas, Yildirim & Yildirim, 2009; Tondeur et al., 2012).

The technological pedagogical content knowledge framework (or technology, pedagogy, and content knowledge [TPACK]; Mishra & Koehler, 2006) has been used extensively across teacher education to guide and inform teacher preparation programs and to measure teacher candidates' learning outcomes (Mouza, 2016). Although this conceptual framework identifies seven knowledge constructs teachers need to integrate technology into instruction effectively, it does not offer specific solutions for developing TPACK among teacher candidates (Mouza, 2016; Niess, 2012). Thus, ascertaining and defining the role all teacher educators are expected to play in the process of preparing teacher candidates to teach with technology is often difficult.

To address this challenge, four teacher education faculty members with educational technology expertise from different teacher preparation programs across the United States used a multimethod research approach to identify a set of technology competencies for teacher educators in hopes of promoting and starting a paradigm shift in teacher education on the ways teacher candidates are prepared to use technology. The result was an 18-month, process-oriented approach that involved national and international experts in the field providing input on the development of a set of TETCs (Foulger et al., 2017).

The goal of this article is to focus on and describe the research project's multimethod approach (Morse, 2003), which emphasized a highly collaborative and participatory set of processes used to build consensus. By sharing our research process in more detail, we hope to encourage others to consider applying similar collaborative and participatory research processes in their own work.

Collectively, this article documents the methodological decisions made by the research team in order to answer the call to develop a common set of technology competencies specific for teacher educators (U.S. Department of Education, 2017). Teacher educators are those individuals who "provide instruction or who give guidance and support to student teachers [teacher candidates], and who thus render a substantial contribution to the development of students into competent teachers" (Koster, Brekelmans, Korthagen, & Wubbels, 2005, p. 157). Research decisions throughout the process were also framed and guided by taking steps to include existing research to guide competency content, involve educational technology experts who work in teacher preparation, and address varied stakeholder needs.

The research team designed the project using a series of three highly collaborative research methods for developing the TETCs. First, a crowdsourcing method was used to gather literature on existing technology competencies specific to teacher educators. After an initial list of technology competencies was extracted from the crowdsourced literature, a Delphi method was used to elicit, distill, and determine the opinions of a panel of experts (Nworie, 2011).

Following six rounds of Delphi input and feedback from educational technology experts, a list of 12 TETCs with related criteria were developed that represented the knowledge, skills, and attitudes all teacher educators need in order to prepare teacher candidates who enter PK–12 classrooms ready to integrate technology to support their teaching and student

learning (Foulger et al., 2017). Last, the TETCs were presented to the field at conferences and a public comment period was used to gather additional feedback related to suitability, allowing more teacher educators additional opportunity to critically appraise the TETCs (Gopalakrishnan & Udayshankar, 2014).

Collectively, these research methods were carefully constructed, highly collaborative, and contributed to building participant consensus throughout the entire 18-month research process. The next sections of this article will discuss specific details that describe the implementation of the multimethod research approach used for this project.

Implementing a Multimethod Research Approach

The TETCs project was intentionally designed to incorporate a multimethod approach that fostered a high degree of collaboration among stakeholders during multiple points of data collection and analysis. Because the overarching goal was to identify technology competencies for all teacher educators, a multimethod research process was implemented and included multiple opportunities for stakeholders' input and feedback throughout the project. As Morse (2003) noted, "Multiple methods are used in a research program when a series of projects are interrelated within a broad topic and designed to solve an overall research problem" (p. 196). A multimethod design can include separate projects that are conducted sequentially in order to inform the research study as a comprehensive whole (Morse, 2003).

The described research project used the methods of crowdsourcing, Delphi, and public comment to identify the TETCs (Figure 1). These multiple methods were conducted sequentially because the crowdsourcing results were used to plan the Delphi process, while the Delphi process findings informed the public comment phase of the research project. Every member of the research team was highly involved with all phases of the research project, compiling and interpreting feedback, while being active and continual facilitators of the communication and feedback aspects of the project. Next, each research method is described briefly and includes a summary of major strengths and challenges for each method.

Crowdsourcing

Crowdsourcing is a Web 2.0 form of outsourcing a task or function to an undefined group of people in the form of an open call (Howe, 2006). Although crowdsourcing started in the business world (Brabham, 2008), it has gained considerable attention and popularity in the academic community (Solemon, Ariffin, Din, & Anwar, 2013). Crowdsourcing facilitates the connectivity and collaboration of many individuals to participate in knowledge generation, and seeks to mobilize competence and expertise, which are distributed among the crowd (Zhao & Zhu, 2014).

In particular, technology enables a process that is highly collaborative and incorporates research perspectives and opinions from individuals who work together across great distances including across countries and continents. The product of a crowdsourcing process is often shared freely and has strong agreement due to the participation of many (Morris & McDuff, 2015).

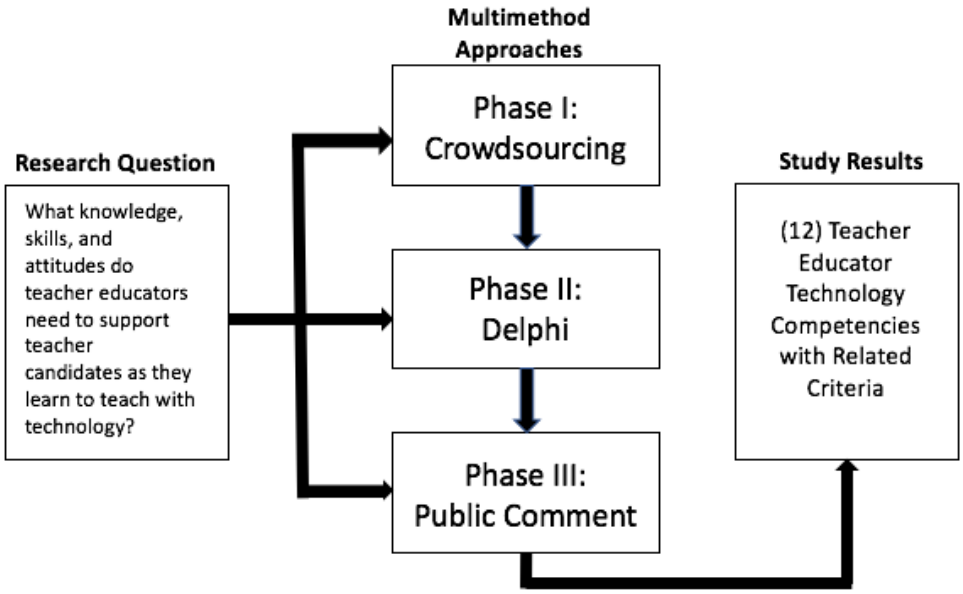

Figure 1. *Implementation of multimethod approaches used to inform research project.*

Collective intelligence or crowd wisdom is a primary strength of crowdsourcing (Brabham, 2008; Howe, 2008). Such a strategy involves sharing the wisdom or knowledge and ideas from a "crowd" in order to solve problems or predict outcomes. It utilizes "collective brain power and energy to complete what they can't do on their own" (Solemon et al., 2013, pp. 2067–2068). Thus, crowdsourcing is a mechanism used to gather opinion and judgment from a large group of individuals in the fraction of time it might take one individual to complete the task.

Today's technology can easily facilitate user-generated content and the exchange of ideas and opinions, so individuals can complete a crowdsourcing task asynchronously and work at their own pace (Brabham, 2008). One challenge associated with the crowdsourcing approach is guaranteeing all who want to participate can and that the crowd that participates represents a diversity of opinion and thought.

Delphi

A Delphi method is a research approach used to validate and refine ideas because it "is designed to both obtain and identify areas of consensus and divergence of opinion" (Nworie, 2011, p. 29). This method allows "a group of individuals, as a whole, to deal with a complex problem" (Linstone & Turoff, 2002, p. 3). The Delphi method involves experts who are carefully selected to share their opinions on an important idea or issue, and then their ideas are synthesized and incorporated into the outcomes (Skulmoski, Hartman, & Krahn, 2007). The process is highly interactive and includes iterative rounds of data collection in order to build reliability, determine suitability, and ultimately yield consensus (Linstone & Turoff, 2002).

Questionnaires are typically constructed for each round of the Delphi process to obtain feedback from a panel of experts. Panelists' responses from each round are analyzed and then used to construct the questionnaire for the next round. This iterative process continues until consensus among the panelists is reached. Consensus is achieved "when a certain percentage of responses fall within a prescribed range for the value being estimated" (Dajani, Sincoff, & Talley, 1979, p. 83).

The Delphi method offers a unique research approach for investigating critical issues, defining problem areas, and identifying best practices and skill sets (Nworie, 2011). Strengths for using the Delphi method include obtaining expert opinion, building consensus, forecasting trends, and interacting with research subjects. The approach is conducive to bringing geographically dispersed individuals together to serve as a panel of experts who share their expertise about the topic under investigation. When using this technique, researchers are able to analyze data based upon the panelists' expert opinions. There are also challenges associated with the Delphi method that are worth noting.

Delphi studies typically involve multiple rounds of data collection and feedback; therefore, it can become a lengthy process and result in the attrition of participants (Nworie, 2011). Slow or nonresponse by participants to a questionnaire during a Delphi round is also a related concern. Another challenge relates to the assumptions that can be made about the expertise and experience of individuals who are selected for the Delphi panel. It is assumed that all individuals selected will have a thorough understanding of the topic under investigation and that personal biases will not influence their responses.

Public Comment

Public comment is used in a variety of contexts to assure a goal will be met before finalization of a product, document, or decision. Successful approaches to public comment depend on information that is reliable, or in the case of human opinion, to people who are well informed on the subject matter. Public comment processes are typically used in high-stakes assessment practices, such as those employed in medical schools and government. Public comment addressing questions posed by a review committee assures specified criteria are met, potential flaw areas are identified, and possible edits are noted with the goal of improving the validity of items.

Modifications are often adopted with the goal of making sure questions are correct, fair, valid, and reliable (Gopalakrishnan & Udayshankar, 2014). The technology industry frequently solicits public comment prior to establishing manufacturing and distribution, to minimize any vulnerabilities, make known any unavoidable risks to consumers, and ensure maximum security. This type of public comment requires both human analysis and technology-based analysis (Quirolgico, Voas, & Kuhn, 2011).

The public comment approach was applied to this research project for the purpose of increasing the visibility of the TETCs with yet another set of stakeholders before the final version of the competencies was released. Thus, one strength of using public comment is for gathering additional insight or thought about a topic, rule, or regulation with the understanding that comments might "have substantial effect" on the final outcome of what is being proposed (Balla, 2014, para. 1). Another strength associated with using public comment involves bringing legitimacy to the process; the public is given a chance to provide feedback so the process appears "democratic and legitimate" (Innes & Booher, 2004, p. 423). One challenge commonly associated with the public comment process is *whose* voice is being heard? Although broad-based participation is typically encouraged,

ascertaining who provides the comments and to what extent those comments are benefiting individual or community interests as a whole is often difficult.

To provide a broad-based international perspective, the public comment phase of the TETCs project as well as the call for literature used during the crowdsourcing phase and the call for Delphi participants utilized international teacher educator networks (i.e., Society for Information Technology and Teacher Education [SITE] and International Society for Technology in Education [ISTE]) and social media networks (e.g., LinkedIn and Twitter) that reached a global audience. Diverse educational technology faculty members from around the world participated in the calls for both literature and Delphi participants and provided feedback during the public comment. For a complete list of literature used during the crowdsourcing phase and a list of Delphi participants, see Foulger et al. (2017).

Additionally, an advisory group was established to inform the research team and the research methodology. Membership on the advisory group consisted of leaders from national and international organizations. The advisory group met periodically with the researchers to provide insight on how to strengthen the methodology. The ultimate goal of the group was to help researchers devise research methodology that would prompt change in the field.

By using all of these methods, the research team sought to create a research methodology that would result in technology competencies *for* teacher educators, that would be representative *of* teacher educators, and that would be created with input *by* teacher educators, so the resulting competencies would be embraced and useful to *all* teacher educators. The next section provides specific details on the multimethod approaches used to encourage collaboration and build consensus among stakeholders.

Collaborative Multimethod Approaches Used to Build Consensus

The multimethod research approach used to develop the TETCs was designed to be highly collaborative and build consensus during and across each phase of the entire research project. Each phase (i.e., crowdsourcing, Delphi, and public comment) of this multimethod approach is described in more detail in the following sections. Special attention is given to explaining how the method contributed to the research project as a whole, the strengths of the research methods from each phase as experienced by the research team of this study, and the ways the results of each phase informed the project's next steps. Specifically, an iterative research process was designed that offered multiple opportunities for stakeholders within and around teacher education to provide input and expert opinion to shape the development of the TETCs.

Phase I: Crowdsourcing

Phase I of the development of the TETCs involved the crowdsourcing of existing literature. The goal of the crowdsourcing process was to identify an initial list of technology competencies for teacher educators that could be extracted from existing literature and then use that list of competencies (grounded in research literature) as a starting point for the Delphi phase. An open call targeting teacher educators and educational technology experts sought literature addressing technology competencies needed by teacher educators who support the development of teacher candidates as they learn to teach with technology. The call for literature was sent through various teacher educator networks (e.g., SITE and ISTE) and social media networks (e.g., LinkedIn and Twitter).

Respondents to the call uploaded 93 related articles and book chapters to a Web portal, which was developed and managed by the research team. To assure a comprehensive review of the literature, the research team also searched for articles and uploaded additional literature to the web portal. After a thorough review of the crowdsourced literature by the research team, literature not specific to teacher educators was eliminated. In the end, 43 articles were selected as a starting point to begin extracting a list of possible technology competencies for teacher educators.

Guidelines for writing an effective competency statement (European Commission: Education and Training, 2013; Sturgis, 2012; University of Texas School of Public Health, 2012) were utilized by the research team to draft a list of initial competencies that stemmed from the crowdsourced literature. This list of technology competencies for teacher educators from the crowdsourced literature included 31 competencies, related criteria aligned with each competency, and references for each competency connected back to the crowdsourced articles.

The research team carefully reviewed the 31 technology competencies with a focus on relevancy, duplication, wording, and quality assurance, according to the guidelines used for writing an effective competency. Several competencies were combined, while others were revised. As a result, an initial list of 24 TETCs were extracted from the crowdsourced literature.

A strength of using the crowdsourcing technique to begin this research project was the ability to reach a large number of national and international experts with related knowledge and research that would have been unknown or otherwise unavailable (Brabham, 2008; Howe, 2008). One challenge the research team encountered with the crowdsourcing phase was sourcing relevant literature and articles that focused on teacher educators. More than half of the articles submitted to the open call were not used because the content was not specific to teacher educators. Phase II of the research project involved using a Delphi method that assisted with the identification and further refinement of the 24 competencies identified from the crowdsourced literature.

Phase II: Delphi Method

To identify participants for the Delphi phase of the research project, an application was developed that included questions about participants' educational organization affiliation, department or college affiliation, role in preparing PK–12 teachers, and country of residence. A broad-based call for participation was posted on the same online networks as the call for literature during the crowdsourcing phase. Forty-six applications were received from individuals who wanted to participate in the Delphi phase of the project. Nworie (2011) recommended selecting divergent experts to help account for future developments in technology, the rapid expansion of pedagogy due to technology use, and any potential or probable changes in policy. Given that the Delphi process was conducted virtually and was not limited to time and location of the experts, a divergence of content expertise, geographic location, organizational affiliations, and college/university settings were considered while selecting the panel participants.

Eighteen participants were selected with the intention of providing a broad perspective as a team through complementary individual expertise, experience, and affiliation. Of the 18 participants selected, 17 agreed to participate in the Delphi phase and signed the Institutional Review Board agreement. During this phase, participants were asked to complete six rounds of data collection and were never made aware of the identity of the other participants.

For each of the six rounds, the Delphi participants were sent a questionnaire with a preamble to guide their thinking, and then a series of questions about the teacher educator competencies or criteria asking them to either provide rankings or an open-ended response to document their thoughts and ideas. The research team compiled and analyzed the responses after each Delphi round, formed the next iteration of the TETCs, and then sent another questionnaire to the participants. This iterative feedback loop allowed the research team to build both quantitative and qualitative consensus on the content of the TETCs and their associated criteria (Dajani et al., 1979).

One strength of the Delphi process used for this research project was the lack of attrition of our Delphi participants. While not all 17 Delphi participants contributed to each of the six rounds, no participant asked to be removed from the study, and all contributed throughout the duration of the process. It is important for researchers to develop strategies that encourage participation because a low response rate during the Delphi process can impact the study's validity (Hsu & Sandford, 2007). In addition, the research team attributes the high participant retention during the Delphi phase to the perceived value of the TETCs and related criteria by the panel participants.

The participants knew they were helping develop a list of competencies to address an identified need within the teacher education community, and most expressed they planned to use the TETCs within their universities to guide technology integration efforts at their institutions. A related strength involved gaining six rounds of expert opinion specifically on the competencies, while building consensus with the Delphi participants during and after each round (Nworie, 2011). Most Delphi studies typically include three or four rounds of expert opinion.

One clear challenge with the Delphi process was the extended time that was necessary to complete this phase of the research project. Designing and sending the questionnaires, allowing time for panel responses, compiling and analyzing the results, and changing the competencies and criteria accordingly, took 4-6 weeks of elapsed time for each of the six Delphi rounds. As noted by Nworie (2011), Delphi studies involving multiple rounds of data collection and feedback can take a significant time to complete. Although the Delphi phase of this research project took 9 months to complete, each round was deemed necessary and important in providing the time needed for input. With the Delphi phase of the research completed, the list of 12 TETCs was ready for public comment.

Phase III: Public Comment

Once the research team was assured the Delphi process had run its course and the Delphi participants were in agreement that the TETCs were indicative of the knowledge, skills, and attitudes all teacher educators needed to support the development of teacher candidates' abilities to teach with technology, the multimethod research approach transitioned to Phase III, public comment. The research-related purpose of using public comment was to provide one final opportunity for additional stakeholders in educational technology and teacher education to offer input on the TETCs. Thus, the research team sought to influence change in the field by (a) distributing the TETCs to as many teacher educators as possible, (b) increasing anticipation for the release of the final TETCs, (c) soliciting input for further refinement, and (d) helping teacher educators begin to reflect on how the TETCs might be used in their college/university.

A brief questionnaire designed by the research team gathered broad-based input from additional stakeholders and organizations in the teacher education community about the perceived usefulness and usability of the TETCs. The questionnaire was sent through the

same channels as were used for the crowdsourcing and Delphi phases. The questionnaire included an explanation of the research project process, a draft copy of the TETCs for participant review, and three questions:

1. What aspects of the TETCs do you/does your organization find most useful?
2. How would you/your organization make use of the TETCs?
3. What concerns do you/does your organization have about the TETCs?

A space for additional comments was also provided so participants could provide insight and input beyond the questions listed on the questionnaire. In this process, anyone (the public) could contribute comments about the TETCs; however, these comments were not made available for other commenters to view. The comments were used by the research team to further refine the TETCs.

Several national and international teacher educators and stakeholders viewed a draft copy of the TETCs during the public comment phase. The public comment process increased awareness in the field about the TETCs and justified the need for the TETCs. Providing a draft copy of the TETCs to the public also allowed those in teacher education who were anticipating the release to begin planning how they might use the TETCs in their colleges and schools of education. In sum, 31 individuals completed the questionnaire on the TETCs during the public comment phase of the project. Twenty-nine responses were from individuals and two responses were from organizations. All responses originated from either the United States or Australia.

Respondents during the public comment phase stated that the TETCs were targeted, helpful, and fitting for the field. Several respondents noted that the TETCs were aligned with the ISTE (2018) Standards for Educators, and one respondent said there was redundancy with the ISTE standards. Some respondents commented they wanted to share the TETCs with senior faculty and administrators at their institutions.

The TETCs seemed to overwhelm a few respondents, who noted concerns such as, “could be misinterpreted as more standards” and “too many.” One respondent discussed fitting terminology (e.g., technology to be an outdated term) and another noted lack of alignment to other educational organizations such as libraries and museums. Because the TETCs are specific to teacher educators who prepare teacher candidates for licensure positions, such comments were noted to be outside the scope of the study and were not included for analysis.

All told, the results and feedback collected from the public comment phase warranted no significant changes to the TETCs; however, the research team opted to modify the initial stem of each competency to include the words “teacher educator” to help clarify the intended audience. The research team hoped this approach would continually remind readers that the TETCs are intended for teacher educators specifically and not for PK-12 teachers.

The public comment phase of this research project provided the research team with additional insight into the development process of the TETCs. Although the TETCs did not change substantially because of any comments received, this phase provided another chance for teacher educators and interested stakeholders to provide feedback about the TETCs and their possible use in teacher education institutions. Because public comment was allowed and considered, it did bring more legitimacy and clarity when developing the final version of the TETCs (Innes & Booher, 2004).

Originally, the goal of the public comment phase was to obtain additional feedback from the field to improve the TETCs before publication. However, once the process began the research team realized that this phase could be used to meet more far-reaching goals related to individual and organizational usability related to the TETCs.

Still, it was challenging using public comment to promote the TETCs by encouraging additional stakeholders to react and provide feedback on the competencies. Although the research team constantly looked for ways to promote collaboration and provide feedback about the TETCs, only 31 comments were received during this phase of the research project. It was unclear how many viewed the draft TETCs but did not provide comments. Broad-based participation during the public comment phase was encouraged, yet only a small percentage of individuals still chose to participate and provide comments (as also in Innes & Booher, 2004). For a list of the findings from the project including the 12 competencies and related criteria and a more detailed description of the data collection and data analysis, see Foulger et al. (2017).

Implications for Research

In order to respond to the need to develop a set of technology competencies for teacher educators (U.S. Department of Education, 2017), the research team designed a research project that used a highly collaborative, multimethod approach. Each method (crowdsourcing, Delphi, and public comment) was conducted separately with a specific purpose in mind, and each was planned sequentially as one approach informed the next (Morse, 2003). Eventually, a list of technology competencies was developed identifying the knowledge, skills, and attitudes all teacher educators need for preparing teacher candidates to use and integrate technology for teaching and learning (Foulger et al., 2017).

Professional organizations have typically taken the lead for developing standards to guide the professional development required for an organization's membership (e.g., Association of Mathematics Teacher Educators, 2017; ISTE, 2018; National Science Teachers Association, 2012; Thomas & Knezek, 2008). Large projects like these are usually funded, seek experts in the field to assist in the development of such standards, and go through multiple iterations of draft documents to reach consensus.

Since this task was similar to what organizations have instituted in the past, the research team carefully designed the project by replicating methods that would be highly inclusive and collaborative by including multiple opportunities throughout the project for expert opinion and comment. It was a process-oriented approach designed to include as many experts (i.e., national and international teacher educators with expertise in educational technology and educational technology experts) as possible in each phase of the research project.

All three methods selected and incorporated into this multimethod design — crowdsourcing, Delphi, and public comment — encouraged gathering collective wisdom and knowledge from a crowd or panel of experts (Brabham, 2008; Howe, 2008; Nworie, 2011; Okoli & Pawlowski, 2004; Rice, 2009; Shelton & Creghan, 2015). As a result of these efforts, other researchers may see the value of combining multiple methods for research projects designed for investigating critical issues or developing skill sets requiring divergence of opinion and the building of consensus.

In order to successfully develop the list of TETCs, the research team placed emphasis on keeping the stakeholders actively involved and engaged in all research activities during each phase and throughout the entire project. Since the target audience for the TETCs was

teacher educators, requests encouraging stakeholders to help with various research tasks were posted using digital and social media outlets. These outlets proved successful for recruiting participants for each phase of the project. For example, 46 individuals applied to participate in the Delphi phase, while 17 (11 females and six males) agreed to participate from this strong and diverse pool of experts. Okoli and Pawlowski (2004) recommended recruiting a panel of at least 10–18 experts for a Delphi study.

Even though a larger panel of experts can present logistical and time investment challenges (Nworie, 2011), the Delphi participants were committed to assisting with the development of the TETCs and remained highly engaged during the 9 months it took to complete six rounds of data collection and analysis. Not all participants completed each of the six rounds, but no participant dropped out entirely. Every round of the Delphi process received feedback from at least 14 participants. This type of active involvement and engagement during each phase of the project was noted and appreciated by the research team.

The stakeholders' commitment during each phase kept the process of using a multimethod approach highly collaborative and informative, especially when used as a sequential research process as different stakeholders became involved with each phase. Other researchers might consider using a multimethod approach when constant feedback and public comment are essential to the research process, especially when gathering iterative phases of data is necessary.

This research project was designed using a multimethod approach, with the primary intent of creating change in teacher education, specifically to impact teaching practices used to prepare teacher candidates who will ultimately use technology appropriately in their future classrooms. Perhaps the research outcomes from this project will initiate a new paradigm of thought, establish strong buy-in, and begin a synergistic movement to impact how teacher candidates are prepared at national and international teacher preparation institutions.

Findings from the research project should encourage teacher educators to review their own practice and make use of the TETCs. In time, teacher educators' practice might change, and then some will embrace an action research approach to systematically examine their own teaching practices with technology (Mertler, 2016). Likewise, administrators in colleges and schools of education may see merit in the findings and create a new vision for preparing teacher candidates to teach with technology within their programs. Using three specific research methods collectively within the framework of one research project permitted the research team to receive opinion, input, and comment from a variety of stakeholders who were committed to promoting change within the teacher education community and, ultimately, developed a set of TETCs that did not exist in the field prior to the research project.

Conclusion

As a result of using a highly collaborative, multimethod research approach, the research team responded to the call for developing a common set of technology competencies for teacher educators (U.S. Department of Education, 2017). The TETCs, the outcomes of using this multimethod research approach, have initiated conversations within the teacher education community for promoting change in how teacher educators use and integrate technology.

This multimethod research approach was designed with the intent of fostering and encouraging collaboration and consensus among stakeholders for the purpose of

promoting change in teacher education. Three specific research methods were used in a sequential and iterative manner with the aim to inform the development of a set of technology competencies for *all* teacher educators.

Critical to the research design was the deliberate attempt to offer multiple opportunities for stakeholders to provide input and feedback, hence the need for using three research methods. These specific methods were selected because each method complemented and built upon the other in terms of obtaining expert opinion, receiving multiple rounds of feedback, and creating consensus in order to have substantial effect on the outcome — change in teacher education and the preparation of teacher candidates. Using any of the three methods in isolation would not have generated the same breadth of results and collaborative feedback.

Author Note

All authors contributed equally to the research and writing process.

References

Agyei, D. D., & Voogt, J. M. (2011). Exploring the potential of the will, skill, tool model in Ghana: Predicting prospective and practicing teachers' use of technology. *Computers & Education*, *56*, 91–100. https://doi.org/10.1016/j.compedu.2010.08.017

Angeli, C., & Valanides, N. (2009). Epistemological and methodological issues for the conceptualization, development, and assessment of ICT–TPCK: Advances in technological pedagogical content knowledge (TPCK). *Computers & Education*, *52*, 154–168. https://doi.org/10.1016/j.compedu.2008.07.006

Association of Mathematics Teacher Educators. (2017). *Standards for preparing teachers of mathematics*. Retrieved from https://amte.net/standards

Balla, S. J. (2014, April 7). *Measuring the impact of public comments*. Retrieved from George Washington University Regulatory Studies Center website: https://regulatorystudies.columbian.gwu.edu/measuring-impact-public-comments

Borthwick, A. C., & Hansen, R. (2017). Digital literacy in teacher education: Are teacher educators competent? *Journal of Digital Learning in Teacher Education*, *33*, 46–48. https://doi.org/10.1080/21532974.2017.1291249

Brabham, D. C. (2008). Crowdsourcing as a model for problem solving: An introduction and cases. *Convergence*, *14*, 75–90. https://doi.org/10.1177/1354856507084420

Dajani, J. S., Sincoff, M. Z., & Talley, W. K. (1979). Stability and agreement criteria for the termination of Delphi studies. *Technological Forecasting and Social Change*, *13*, 83–90. https://doi.org/10.1016/0040-1625(79)90007-6

Ertmer, P. A., & Ottenbreit-Leftwich, A. T. (2010). Teacher technology change: How knowledge, confidence, beliefs, and culture intersect. *Journal of Research on Technology in Education*, *42*, 255–284. https://doi.org/10.1080/15391523.2010.10782551

European Commission: Education and Training. (2013, July). Supporting teacher competence development for better learning outcomes. Retrieved from

http://ec.europa.eu/assets/eac/education/experts-groups/2011-2013/teacher/teachercomp_en.pdf

Foulger, T. S., Graziano, K. J., Schmidt-Crawford, D. A., & Slykhuis, D.A. (2017). Teacher educator technology competencies. *Journal of Technology and Teacher Education*, *25*, 413–448. Retrieved from http://site.aace.org/tetc/

Gopalakrishnan, S., & Udayshankar, P. M. (2014). Question vetting: The process to ensure quality in assessment of medical students. *Journal of Clinical and Diagnostic Research*, *8*(9), XM01–XM03. https://doi.org/10.7860/JCDR/2014/9914.4793

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

Howe, J. (2006). The rise of crowdsourcing. *Wired Magazine*, *14*(6), 1–4.

Howe, J. (2008). *Crowdsourcing: How the power of the crowd is driving the future of business*. New York, NY: Random House.

Hsu, C.-C., & Sandford, B. A. (2007). Minimizing non-response in the Delphi process: How to respond to non-response. *Practical Assessment, Research & Evaluation*, *12*(17), 1–6.

Innes, J. E., & Booher, D. E. (2004). Reframing public participation: Strategies for the 21st century. *Planning Theory & Practice*, *5*, 419–436.

International Society for Technology in Education. (2018). *ISTE standards for educators*. Retrieved from https://www.iste.org/standards/for-educators

Koster, B., Brekelmans, M., Korthagen, F., & Wubbels, T. (2005). Quality requirements for teacher educators. *Teaching and Teacher Education*, *21*, 157–176. https://doi.org/10.1016/j.tate.2004.12.004

Linstone, H. A., & Turoff, M. (Eds.). (2002). *The Delphi method: Techniques and applications*. Newark, NJ: New Jersey Institute of Technology. Retrieved from https://web.njit.edu/~turoff/pubs/delphibook/delphibook.pdf

Mertler, C. A. (2016). *Action research: Improving schools and empowering educators* (5th ed.). Thousand Oaks, CA: Sage.

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, *108*, 1017–1054.

Morris, R. R., & McDuff, D. (2015). Crowdsourcing techniques for affective computing. In R. A. Calvo, S. D'Mello, J. Gratch, & A. Kappas (Eds.), *Oxford handbook of affective computing* (pp. 384–395). https://doi.org/10.1093/oxfordhb/9780199942237.013.003

Morse, J. M. (2003). Principles of mixed methods and multimethod research design. In A. Tashakkori & C. Teddlie (Eds.), *Handbook of mixed methods in social & behavioral research* (pp. 189–208). Thousand Oaks, CA: Sage.

Mouza, C. (2016). Developing and assessing TPACK among pre-service teachers: A synthesis of research. In M. C. Herring, M. J. Koehler, & P. Mishra (Eds.), *Handbook of technological pedagogical content knowledge (TPACK) for educators* (2nd ed., pp. 169–190). New York, NY: Routledge.

National Science Teachers Association. (2012). *2012 NSTA standards for science teacher preparation*. Retrieved from https://www.nsta.org/preservice/

Niess, M. L. (2012). Teacher knowledge for teaching with technology: A TPACK lens. In R. N. Ronau, C. R. Rakes, & M. L. Niess (Eds.), *Educational technology, teacher knowledge, and classroom impact: A research handbook on frameworks and approaches* (pp. 1–15). https://doi.org/10.4018/978-1-60960-750-0.ch001

Nworie, J. (2011). Using the Delphi technique in educational technology research. *TechTrends*, *55*(5), 24–30. https://doi.org/10.1007/s11528-011-0524-6

Okoli, C., & Pawlowski, S. D. (2004). The Delphi method as a research tool: An example, design considerations and applications. *Information & Management*, *42*, 15–29. https://doi.org/10.1016/j.im.2003.11.002

Ottenbreit-Leftwich, A. T., Glazewski, K. D., Newby, T. J., & Ertmer, P. A. (2010). Teacher value beliefs associated with using technology: Addressing professional and student needs. *Computers & Education*, *55*, 1321–1335. https://doi.org/10.1016/j.compedu.2010.06.002

Quirolgico, S., Voas, J., & Kuhn, R. (2011). Vetting mobile apps. *IT Professional*, *13*(4), 9–11. https://doi.org/10.1109/MITP.2011.73

Rice, K. (2009). Priorities in K–12 distance education: A Delphi study examining multiple perspectives on policy, practice, and research. *Educational Technology & Society*, *12*(3), 163–177.

Shelton, K., & Creghan, K. A. (2015). Demystifying the Delphi method. In *Research methods: Concepts, methodologies, tools, and applications* (pp. 84–104). https://doi.org/10.4018/978-1-4666-7456-1.ch005

Skulmoski, G. J., Hartman, F. T., & Krahn, J. (2007). The Delphi method for graduate research. *Journal of Information Technology Education*, *6*, 1–21.

Solemon, B., Ariffin, I., Din, M. M., & Anwar, R. M. (2013). A review of the uses of crowdsourcing in higher education. *International Journal of Asian Social Science*, *3*, 2066–2073.

Sturgis, C. (2012, July). *The art and science of designing competencies*. Retrieved from International Association for K–12 Online Learning website: https://www.inacol.org/resource/the-art-and-science-of-designing-competencies/

Thomas, L. G., & Knezek, D. G. (2008). Information, communications, and educational technology standards for students, teachers, and school leaders. In J. Voogt & G. Knezek (Eds.), *International handbook of information technology in primary and secondary education* (pp. 333–348). https://doi.org/10.1007/978-0-387-73315-9_20

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

Tondeur, J., Roblin, N. P., van Braak, J., Fisser, P., & Voogt, J. (2013). Technological pedagogical content knowledge in teacher education: In search of a new curriculum. *Educational Studies*, *39*, 239–243. https://doi.org/10.1080/03055698.2012.713548

University of Texas School of Public Health (2012). *Competencies and learning objectives*. Retrieved from https://sph.uth.edu/content/uploads/2012/01/Competencies-and-Learning-Objectives.pdf

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

Zhao, Y., & Zhu, Q. (2014). Evaluation on crowdsourcing research: Current status and future direction. *Information Systems Frontier*, *16*, 417–434. https://doi.org/10.1007/s10796-012-9350-4