Four pillars of technology infusion: Using Q methodology to examine candidate perspectives on their preparation to use technology

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Abstract

Technology infusion has been proposed as essential in preparing teacher education candidates to use technology within their own instructional practices. Foulger (2020) articulated four pillars needed for technology infusion. These include the educator preparation program (EPP) curriculum, candidate beliefs and efficacy, how technology has been modeled by faculty, and whether candidates have had opportunities to critically think about and use technology throughout their preparation including within clinical practice. This study examines teacher education candidates' perspectives about their preparation to use technology within their respective programs. Q methodology and factor analysis were used to identify how candidates (N=90) from seven institutions across the U.S. characterized their preparation as aligned with the four pillars of technology infusion in teacher

preparation.
Keywords: *Technology Infusion, Technology Integration, Teacher education, Q Methodology*

Introduction

While government agencies and professional organizations continue to advocate for increased efforts to prepare teacher candidates (TCs) to use technology, this goal remains elusive. A recent summary of research by the International Society for Technology in Education (ISTE) highlights ongoing issues in preparing teachers to use technology (ISTE, 2023). Three key findings include:

- … the urgent need for greater faculty expertise in digital pedagogy to drive formative change…
- … new teachers lacked confidence using learning technologies…
- … a need for greater breadth, depth, and quality to facilitate preservice teachers' development of digital pedagogy skills. (p.3)

ISTE survey results emphasized the need for faculty to model digital pedagogical skills, with only 9% of Educator Preparation Programs (EPPs) reporting that every faculty member embraces and models instructional technology. Fifty-six percent of the candidates who participated in a separate survey described by ISTE and conducted by Jenna Conan Simpson indicated they lacked confidence in using learning technologies effectively. These ongoing challenges suggest the need for a new paradigm and how TCs are prepared to use technology within their instructional practice.

Literature Review and Conceptual Framework

Technology infusion has been proposed as a new paradigm for preparing TCs to use technology (Williamson et al., 2023). Emerging from federal calls for technology to be used program-deep and program-wide within educator preparation (DOEOET, 2017), researchers focusing on technology infusion have challenged EPP's to improve educator preparation and expand opportunities for candidates (Borthwick et al., 2020). Williamson et al. (2023) identified ten characteristics and indicators of technology-infused programs. These include: pervasive technology content; shared responsibility; unified vision; planned curriculum; developmental practice-based approach; varied, multi-stage assessment for continuous improvement; informed design and renewal; technology competent teacher educators; ubiquitous access; and leadership support for systemic change. They conclude, "... a community of practice dedicated to studying and sharing their cyclical design experiences will advance the cause and produce multiple ways of achieving program-deep and program-wide approaches to teacher technology preparation" (p. 221).

Four pillars play a role in technology infusion practices in educator preparation programs: technology integration curriculum, modeling technology integration, practice and reflection, and development of technology self-efficacy (Foulger, 2020). As such, these pillars served as the conceptual framework for our investigation of teacher candidate perspectives on their preparation to use technology for teaching and learning. A special issue of the *Journal of Contemporary Issues in Technology and Teacher Education* (Volume 23, Issue 1, 2023) provided literature summaries related to each of the four pillars of technology infusion which are described below (Graziano et al., 2023, Jin et al., 2023; Sprague et al, 2023, Warr et al., 2023; Williams et al., 2023).

Pillar One. Pillar one emphasizes the need for careful design of a technology infused curriculum. The curriculum includes the content—standards, core values, and contextual knowledge. A curricular plan should also include situated practice (in content areas and professional communities) and "touchpoints"—carefully sequenced opportunities for TCs to observe and use effective technology integration practices. These touchpoints can spread across the curriculum, including in foundational educational technology courses, methods courses, clinical experiences, etc. When designing a technology infused curriculum, it is critical to consider the program and community context, including the values, history, needs, and policy of the program and community. The design process should enable continual evaluation and be responsive to shifting contexts, including technological progress.

Pillar Two. Researchers agree that modeling technology integration is a useful and much-needed strategy in teacher education programs (e.g., Sardone, 2019; Tondeur et al., 2018). Moreover, well-designed modeling strategies can bring positive outcomes (e.g., Cheng et al., 2022; Neumann et al., 2021; Zipke et al., 2019). However, modeling should not be a single strategy. Instead, it is usually a combination of various strategies formed together in a special sequence due to design considerations. Thus, it is necessary to examine the design of modeling instructional technology integration in teacher preparation programs to guide practice. Jin et al. (2023) analyzed 65

articles and proposed a new modeling design, as well as research-based principles, implementation strategies, and teacher educator competencies.

Pillar Three. The focus of Pillar Three is on clinical practice. The goal of Pillar Three is to provide TCs with the opportunity to plan and teach with technology and to reflect on the experience. Providing these opportunities helps candidates to develop the knowledge, skills, and self-efficacy to integrate technology into their practice. For TCs to have these opportunities, it is essential that teacher education programs and PK-12 schools work together to provide a unified vision of how to teach with technology.

Pillar Four. Teacher Self-Efficacy in Technology Integration (TSEinTI) refers to teachers' confidence in their ability to integrate technology into classroom teaching and learning successfully. This concept was developed from a synthesis of relevant literature about the influences of teacher preparation to use technology, such as environments, attitudes, beliefs, support, and resources. It describes how teacher preparation can promote TSEinTI through programs that (1) provide authentic experiences requiring candidates to design technology-integrated lessons, (2) incorporate reflective practices, and (3) assess candidate growth in TSEinTI (Williams et al., 2023). Program culture and leadership also play a key role in establishing expectations for faculty to model technology use, providing infrastructure and equitable access to technology, and developing teacher educators' technology competencies. Adopting an infusion approach will support TCs' development to effectively leverage technology in their future classrooms.

With the four pillars as a conceptual framework, the following research questions guided our inquiry.

- RQ1: What are teacher education candidates' perspectives about (a) the design of their educator preparation program to integrate technology and (b) instructor modeling and opportunities for practice? (Pillars One & Two)
- RQ2: What are teacher education candidates' perspectives on how EPPs implement field placements to support candidate development to use educational technology? (Pillar Three)
- RQ3: What are teacher education candidates' beliefs about the value of educational technology and their self-efficacy in using technology for teaching and learning? (Pillar Four, TSEinTI)
- RQ4: How might Q methodology serve as a tool for teacher education candidates to provide feedback on their technology education? (Factor Analysis)

Methods

A mixed methods approach involving Q methodology (McKeown & Thomas, 2013; Stephenson, 1935, 1953) coupled with collection of demographic and qualitative responses was used. Participants were asked to complete a forced Q sort of 43 statements aligned with the four pillars of technology infusion in teacher preparation. The statements were based on prior research (Clausen et al., 2023). The statements were reviewed and revised with the lead authors of literature summaries published in 2023 (Jin et al., 2023; Sprague et al, 2023, Warr et al., 2023; Williams et al., 2023) during a series of meetings over a period of several months. The final number of statements aligned with each pillar varied: 10 statements for Pillar One, 17 statements for Pillar Two, 5 statements for Pillar Three, and 11 statements for Pillar Four. Using EQ Web Sort (Banasick, 2022), participants completed a forced sort that required a selected number of statements to be placed in nine columns across a continuum from -4 (Most Unlike their beliefs and experiences) to +4 (Most Like their beliefs and experiences). Participants were then asked to provide a brief rationale for their placement of statements in the -4 and +4 columns. The entire process–from review and signature of a consent form to submitting the Q sort and demographic and qualitative responses–was completed online.

Data Sources. Researchers from seven institutions (five public and two private) across the U.S. recruited TCs from a variety of program areas who were enrolled in or had recently completed their final practicum as volunteer participants. There were 90 total participants with a range from 2 to 27 TCs from each institution. Researchers actively teaching classes and/or researchers whose data collection appeared to have the active support of program administrators seemed to be able to recruit volunteers more readily. Some data was collected during regularly-scheduled class sessions, and some data was collected during out-of-class time. No participant was "required" to submit a Q sort even if they used the online software to sort the items provided. At one institution, TCs sometimes worked in small groups to submit a "collaborative" Q sort. Recruitment of participants took place online at some institutions and in person at others.

Data Analysis. The authors examined data in multiple ways: the correlation of participant sorts with one another to identify groups of similar participants (factors) (Watts & Stenner, 2012), pillar-aligned statements placed

at the -4 and -3 end of the continuum contrasted with the statements placed at the +4 and +3 end of the continuum for a specific pillar, and number of candidates from a single institution sorting in similar ways. KADE software (Banasick, 2021) was used to identify factors via varimax rotation and principal components analysis and EQ Web Sort (Banasick, 2022) provided a file with participants' qualitative responses. A Google form was used to collect and review demographic data.

Results

Findings across all EPPs were compiled and analyzed in alignment with the four pillars of technology infusion. To address the first three research questions, results for each of the four pillars are presented with a brief summary of the data most strongly aligned with TCs' perspectives of beliefs and experiences during their preparation programs.

Pillar One emphasizes the need for thoughtful design of a technology infusion curriculum. There were a total of ten statements (QS6-15) aligned with Pillar One. Table 1 presents the statements with the highest frequencies of "Most Unlike" and "Most Like" TC responses from the 90 participants in this study.

Table 1
Frequency of Participant Responses (-4, -3, +3, +4) for Selected Statements Aligned With Pillar One

	Most Unlike Me		Most Like Me	
Q Statements	**-4**	**-3**	**3**	**4**
7. My teacher education program provides opportunities for discussion, reflection, and feedback on ways to use technology for teaching and learning.	0	4	***11***	***11***
8. My teacher education program has an assessment structure in place to ensure that teacher candidates can implement technology effectively in support of PK12 learning.	***11***	***12***	2	4
10. My teacher education program introduced frameworks for technology integration (e.g., TPACK, SAMR, Triple E).	***44***	***5***	5	3
11. My teacher education program has a curriculum designed to help candidates meet the International Society for Technology in Education (ISTE) Standards for Educators.	***17***	***14***	5	2
13. Technology use for teaching and learning is expected and supported in my coursework and school-based experiences.	3	7	***16***	***8***
14. My teacher education program affirms the importance of equitable access to technology for PK12 learners.	3	4	***10***	***9***

Q sorts submitted by participants presented particularly negative perspectives related to assessment structures within their EPP (QS8), implementation of technology integration frameworks (QS10), and curriculum intended to meet ISTE standards (QS11). Teacher candidates' reasons for the placement of these statements in the -4 column (Most Unlike me/my experiences) illustrate their responses related to this pillar.

- "We do not have an assessment structure in place to ensure that we are implementing technology" (MW1A3).
- "I have never heard of TPACK SAMR Triple E or any other framework for tech integration in the teacher education program" (W2W07).
- "I do not believe we have any curriculum designed for Technology in Education Standards for Educators and I'm honestly not too sure what that even is because it has not been talked about at my university" (MW3A6).

On the other hand, TCs' Q sorts represented more positive feedback related to program opportunities for reflection and feedback (QS7), program expectation for use of technology by TCs in coursework and field experiences (QS13), and affirmation of the importance of PK12 learner equitable access to technology (QS14). Candidates stated:

- "Many of our in-class conversations centered on how we can use technology not only to reflect on goals and previous work as well as how we can use technology to have students reflect on their viewpoints" (W2T02).
- "Many of our assignments use a form of technology. We use it during class for homework and many different teaching resources. It is expected that it is part of our lessons and coursework" (MW3A8).
- "All of my courses are based in equitable access to education. Technology is a learning tool that we have discussed and those discussions were based in equitable access to tech for students" (E1S1).

Pillar Two encompasses descriptions of how teacher educators can model technology integration across various learning environments TCs may encounter. Seventeen statements (QS16-32) were aligned with Pillar Two. Three statements representing key areas of focus were statements 19, 24, and 32. Table 2 represents the Pilar Two statements with the highest frequencies of "Most Unlike" and "Most Like" TC responses from the 90 participants in this study.

Table 2

Frequency of Participant Responses (-4, -3, +3, +4) for Selected Statements Aligned With Pillar Two

	Most Unlike Me		Most Like Me	
Q Statements	**-4**	**-3**	**3**	**4**
19. Teacher education instructors model basic tech troubleshooting skills during teaching.	***25***	***14***	4	2
24. Teacher education instructors provide opportunities for candidates to practice teaching online and/or in blended/hybrid learning environments.	***15***	***16***	4	3
32. Teacher education instructors provide candidates with explicit evaluation criteria for technology integration in assignments and field experiences.	***6***	***17***	1	2

Q sorts submitted by participants did not rate modeling as a strong characteristic of their programs. Among the 17 statements related to modeling technology use, three statements (QS19, 24, 32) were identified among the "Most Unlike" ratings. These three statements center on instructor modeling of technology troubleshooting (QS19), creating opportunities for candidates to practice in blended/online learning contexts (QS24), and explicit assessment and evaluation criteria for technology integration (QS32). Qualitative comments verified these findings through TCs' descriptions of how some instructors were not comfortable with modeling technology integration and held negative attitudes toward technology integration.

- "I have never seen a professor or instructor model troubleshooting. It seems as if I am expected to know or learn for myself" (E268).
- "Currently there is not an opportunity to practice teaching online in my location. Most schools are no longer providing online or hybrid learning except for specific schools that are designed to be online" (MW2A1).
- "I can only think of one time where we had to incorporate technology into a lesson however we did not actually use the program just say how we would use it. Other than that I have not been told that I have to use technology for anything" (MW3A3).

Pillar Three comprises the design and support of iterative practice and reflection during clinical practice. Five statements in the Q sort (QS33-37) were aligned with Pillar Three. Key statements included QS 33, 36, and 37, based on responses from the 90 teacher candidates in the study. Table 3 presents statements with the highest frequencies of "Most Unlike" and "Most Like" teacher candidate responses.

Table 3

Frequency of Participant Responses (-4, -3, +3, +4) for Selected Statements Aligned With Pillar Three

	Most Unlike Me		Most Like Me	
Q Statements	**-4**	**-3**	**3**	**4**
33. My teacher education program has university supervisors who are knowledgeable about how to meaningfully integrate technology to enhance PK12 student learning.	***6***	***11***	4	4
36. My teacher education program and my field placement are similar in terms of the types of resources available, including up-to-date hardware and software.	***7***	***12***	6	4
37. My teacher education program has school-based cooperating/mentor teachers who are knowledgeable about how to meaningfully integrate technology to enhance PK12 student learning.	***5***	***14***	9	3

TCs often identified negative perspectives of their opportunities to practice teaching with technology. They indicated that university supervisors and mentor teachers were not knowledgeable in how to meaningfully integrate technology to support K12 student learning (QS33, 37) and that there were differences between the technology available at the university and at the PK12 school-based environments (QS36).

- "The program does not always teach effectively about how to integrate technology to enhance to student

learning they just state its important" (E249).

- "My field placement has technology that is out of date compared to my university" (MW1A11).
- "My mentor teachers haven't really incorporated much technology" (MW1A8).

Pillar Four explicates TCs' beliefs regarding the value of technology for learning and the development of their self-efficacy in technology integration (TSEinTI). There were 11 statements aligned with Pillar Four (QS1-5 and 38-43). Six key statements relate to TCs' perceptions of beliefs and confidence in using technology within their instructional practices. Table 4 presents the statements with the highest frequencies of "Most Unlike" and "Most Like" TC responses from the 90 participants in this study.

Table 4

Frequency of Participant Responses for Selected Statements Aligned With Pillar Four

	Most Unlike Me		Most Like Me	
Q Statements	**-4**	**-3**	**3**	**4**
1. Technology allows PK12 students to collaboratively explore real-world issues and problems, develop ideas and theories, and pursue answers and solutions.	4	0	***15***	***23***
2. Technology allows PK12 students to understand and communicate complex ideas by creating or using a variety of digital objects such as visualizations, and models or simulations.	0	5	***14***	***16***
3. Technology can support PK12 student agency and voice in representing personal or community knowledge and experiences.	1	8	***11***	***14***
4. Technology can provide greater access to information and diverse viewpoints.	0	2	***20***	***31***
38. My lessons integrate technology to support critical thinking and knowledge construction.	2	7	***14***	***10***
39. I can match content with effective technology (e.g., virtual manipulatives for math, digital stories for language arts and social studies).	5	5	***16***	***14***

Participants loaded strongly in "Most Like Me" in relation to six statements (QS1, 2, 3, 4, 38 and 39). These statements are about TCs beliefs and efficacy, and how those perspectives influence their technology integration practices.

- "Using technology in the classroom allows students to explore beyond the textbook and the bubble that they live in every day (W2T03).
- "I think it is so important that we use technology because it allows us that discussion. There are so many different perspectives in the world that it's important that we hear from each-other and are able to open up that discussion (MW1A13)"
- "I am always open to trying something new that may be more exciting for students especially with the support of my cooperating teachers" (MW3A9).
- "I feel that I am able to do this based off of the training that I went in [sic] the past four years." (MW1A17).

To address the fourth research question, we completed a statistical analysis of the 90 Q sorts collected across seven institutions. Using KADE Software (Banasick, 2021), we identified four factors, with 67 participants loading on a factor. Table 5 includes the number of participants loading on each factor, ranging from 35 on Factor A, 14 on Factor B, to 9 on Factors C and D. Both Factors C and D had participants who loaded in a bipolar manner—indicating the same Q statements were important—but with a "mirror image" configuration (Watts & Stenner, 2012). Following Table 5, we briefly summarize each factor based on our review of distinguishing statements and exemplary sorts for each factor plus explanations from participants for statements placed at the +4 or -4 ranks. A full report of the factor analysis and related implications will be provided in a future manuscript.

Table 5

Participant Perspectives Identified Through Factor Analysis

Factor	Brief Description	Participants Loading	Bipolar Participants	Institutions Represented
Factor A	Strong TSEinTI	35	0	6

Factor B	Disconnect of Coursework and Field Experiences	14	0	6
Factor C	Encouraged Yet Unconvinced	9	2	3
Factor D	Supported but More to Learn re. Tech Integration	9	3	4

Strong TSEinTI. The Q sorts completed by the 35 participants who loaded on Factor A revealed teacher candidate confidence in integrating technology for critical thinking and knowledge construction (+3), and development of lessons for PK12 creation of original works (+1). Results also reflected EPP curricular design with a shared vision (+2) and program expectations and support for technology use in courses and field experiences (+3).

Disconnect of Coursework and Field. Although Q sorts completed by participants on this factor suggested expectations for technology use (+1) and support for candidate evaluation, curation, and creation of digital resources (+3), Factor B participants noted a lack of shared vision across courses and field experiences related to technology integration (-4). Results also showed a lack of knowledgeable cooperating/mentor teachers and university supervisors (-2) and access to technology resources in the field (-2).

Encouraged Yet Unconvinced. Q sorts completed by these participants suggested that candidates felt sustained support and encouragement (+4) and empowered to undertake technology integration efforts (+2). However, Q sorts completed by these participants reflected less opportunity (-2) and lower expectation and support (-3) for practicing technology integration. They also did not believe that tech-infused teaching methods were more effective than traditional methods (-3). As this was a bipolar factor, several participants who loaded on this factor had opposing rankings of these same Q statements.

Supported but More to Learn re. Tech Integration. Participants on this factor indicated expectations, opportunities, and support were prominent (+4). They also had instructors who both modeled (+3) and provided opportunities for them to practice teaching in online/hybrid learning environments (+4). Nevertheless, they did not identify skill in matching effective technology with content matter (-4), or program focus on using technology for problem-solving (-3), or their own lessons integrating technology for critical thinking and knowledge construction (-2). As this was a bipolar factor, several participants who loaded on this factor had opposing rankings of these same Q statements.

Discussion/Implications

Factors represent varied viewpoints across the 90 participants, but also across participants at a single institution. We observed that at six of the seven institutions, TCs loaded on several different factors. In fact, the three institutions with the largest number of participants had TCs that loaded on four different factors; based on their Q sorts, not everyone's perceptions correlated strongly with others attending their institution.

Further, in examining placement of Q statements for Pillar One (QS6-15), we found responses from TCs at the same institution often represented a range of rankings. For example, at one institution (E2) candidate responses were at *every* rank from -4 to + 4 for QS6, 10, 11, and 14. Thus, it seems clear that candidates were not having consistent experiences at their institution in terms of opportunities to practice technology integration, instruction related to frameworks for technology integration, curriculum to meet the ISTE standards, and affirmation of the importance of PK12 equitable access to technology. The disparate and inconsistent responses of participants within other institutions were also evident.

Statistically significant consensus items across all four factors included QS17, 19, and 26. Two of these were placed at 0 or -1. More revealing was QS 19, instructor modeling of basic tech troubleshooting skills during teaching, which was placed at -3 or -4 by all four factors. Perhaps teacher educators primarily use hardware and software with which they are very familiar, call on university or college tech support when they experience difficulty, or avoid using new or complex tools. Though not statistically significant, on a more positive note, all four factors placed QS 7, provision of opportunities for discussion, reflection and feedback on ways to use technology for teaching and learning, at +1 (Factor A) or +2 (Factors B, C, and D).

The four factor solution also revealed seven items (QS1,11, 13, 24, 25, 39, 40) where factor rankings ranged from -4 to +3 or +4, or -3 to +4; these included statements about curriculum designed to meet the ISTE Standards, TC opportunities to practice teaching online and/or in blended/hybrid learning environments, expectation and support for technology use in courses and field work, and ability to match effective technology with content matter. Once again, TC responses reveal very different experiences in their preparation to use technology for teaching and learning. Further, these items represent technology infusion via program elements within Pillars One, Two, Three, and Four.

Prior research of teacher education faculty and candidates using Q methodology (Clausen et al., 2021, 2023a, 2024) identified EPPs' lack of a structured technology-infused curriculum and assessment system designed to address standards and frameworks. As stated by one participant in the current study, "I don't believe I have been assessed on implementing technology at all" (E1S8). Until EPP leadership, at multiple levels, develops a vision and establishes systematic processes, technology infusion will remain hit or miss. Curriculum design, the modeling pre-service teachers receive, technology-infused clinical practices, and development of candidate efficacy are all dependent on the contextual factors and the stakeholders with whom candidates interact. Williamson, et al. (2023) categorize technology infusion in teacher preparation as a "new paradigm," and adoption of the paradigm as a challenging endeavor requiring the participation of a community of inquiry and practice. Broad stakeholder involvement to address the four foundational pillars examined in our study requires agreement on competencies and expectations to be met by teacher candidates (e.g., licensure requirements), faculty role models, and field-based mentors and supervisors, and the steps to build individual and community-wide commitment to achieving change (South & Song, 2020). Tables and checklists provided in the CITE 2023 journal pillar summaries (Jin et al., 2023; Sprague et al, 2023; Warr et al., 2023; Williams et al., 2023) provide considerations for how to design, improve, or expand essential program elements to assure candidate knowledge, skills, and dispositions.

Limitations

Q methodology allows for a research approach to gather perspectives across a variety of populations. We reviewed analytics provided by EQ Web Sort (Banasick, 2022) and eliminated sorts based on minimal time spent on sorting and incomplete qualitative responses. A subsequent manuscript will include a full analysis of each factor. We will also take a further look at the submission of several sorts completed by small groups of TCs rather than by individuals.

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