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A mixed-methods study of novice teachers' technology integration: Do they leverage their TPACK knowledge once entering the profession?

Rachel Karchmer-Klein[a] and Haruka Konishi[b]

[a] School of Education, University of Delaware, Newark DE, USA
[b] Department of Education, Missouri Western State University, St. Joseph, MO, USA

Contact
Rachel Karchmer-Klein
School of Education, University of Delaware, Newark, DE, USA.
karchmer@udel.edu

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Abstract

Research indicates educators benefit from developing Technological Pedagogical Content Knowledge (TPACK), a combination of constructs that inform the design of pedagogically-sound technology-integrated instruction. Applying a mixed-methods explanatory sequential study design, we exam-ined if and how novice K-12 teachers, who developed TPACK during the same teacher education program, transferred that knowledge to their full-time teaching upon graduation. A total of 50 participants completed a survey that explored their perspectives of technology integration. Interviews were conducted with 20 participants to further examine the survey results. Three significant findings were identified: (1) participants perceived technology integration as important to their teaching, (2) a dis-connect existed between teachers' perceived importance of technology-integrated activities and actual integration, and (3) persistent barriers continued to challenge teachers' integration of technology.

Teacher licensure programs serve a critical role in how digital tools may be implemented in classrooms. They shape preservice teachers' (PST) beliefs about technology by not only introducing effective instructional practices, but also providing opportunities to utilize different technologies in a range of classroom contexts (Paratore et al., 2016). Yet, the quality of preparation varies across programs (Tondeur et al., 2017) leaving novice teachers with gaps in their understanding of how to fully immerse students in effective technology-based instruction. Such disparities were prominently illustrated in the spring of 2020 and the subsequent 2020–2021 academic year when educators around the world were required to shift to emergency remote teaching in light of the Covid-19 pandemic (Ferdig et al., 2020). Novice teachers, for instance, had difficulty using digital tools to conduct formative assessments due to limited exposure of such practices in their training (König et al., 2020).

How then should PST be prepared to design and implement meaningful technology integrated instruction so they apply that knowledge upon commencing a fulltime teaching position? There is a robust body of work indicating that educators benefit from developing Technological Pedagogical Content Knowledge (TPACK), situated knowledge that informs effective integration of digital tools in curriculum-based teaching (Koehler & Mishra, 2009). Yet, to the best of our knowledge, no studies have examined how PST, who developed TPACK during the same teacher education program, transfer that knowledge to their full-time teaching upon graduation. This is critical to study because not until new teachers engage in the everyday responsibilities associated with teaching will they have opportunities to adequately practice what they learned in their preservice teacher education program.

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The mixed-methods explanatory sequential study (Creswell & Clark, 2018) presented here identifies factors contributing to teachers' technology integration their first years of full-time instruction by examining survey and interview data collected from recent graduates of the same teacher licensure program.

Theoretical and empirical framework

Teachers' beliefs and technology integration

Teachers' beliefs are perceptions that scaffold one's thoughts and behaviors (Fives & Buehl, 2012). There is a literature base confirming that teachers' beliefs about technology are related to how much ICT are accepted and utilized in the classroom (Tondeur, 2020). We reviewed recent research and identified three broad themes that informed our understanding of how and why the NT in this study may or may not integrate technology.

One theme is the "bi-directional" (Tondeur et al., 2017, p. 561) relationship between teacher beliefs and technology integration. Teachers who are immersed in technology-rich environments with support may be exposed to ways the affordances of ICT can create student-centered learning opportunities and, in turn, their beliefs about teaching may shift away from didactic lesson design (Chen, 2008) Conversely, existing pedagogical beliefs may shape the way technology is leveraged in the classroom. Teachers who describe their instruction as teacher-centered tend to utilize digital tools for drill and practice (Martin & Vallance, 2008; Tondeur, 2020). Educators who hold constructivist, student-centered beliefs are more likely to leverage technology to engage students in collaborative problem-solving activities (Ertmer et al., 2015).

A second theme reflects how teachers' attitudes toward technology influence their use of ICT in classrooms with students. Okumuş et al. (2016) found that higher self-efficacy with certain technology tools led to greater integration. Not surprising, negative or neutral views of technology may lead to less technology integration. For example, teachers who value traditionally printed materials (i.e., books) may prefer them for classroom learning rather than connecting students to open resources on the Internet (Mama & Hennessy, 2013).

Third, the professional context to which digital tools are applied can influence teachers' beliefs about tech integration (Fives & Buehl, 2012). Peer support can bolster or discourage how teachers feel about using digital tools (Okumuş et al., 2016) and student skill-level, age, and interest in using technology in learning can influence the way instruction is designed (Angeli & Valanides, 2009). In fact, a recent study found that a greater appreciation of technology-based instruction by students and parents affected primary school teachers' attempts at using ICT in their practice (Roussinos & Jimoyiannis, 2019).

Importantly, research suggests NTs' beliefs fluctuate. There is evidence that NT encounter a shock to their system when they begin full time teaching (Hobson & Ashby, 2012). Some of this can be accounted for by dramatic differences between their teacher education programs and the realities of the classroom. Another reason could be that NT undergo a transition period where they may lack confidence as they acclimate to their current environments, regardless if they align with the practices learned during their preparation (Voss & Kunter, 2020). Teacher candidates tend to enter teacher licensure programs viewing teaching as "dispensing information" (Brookhart & Freeman,1992, p. 51), graduate with more constructivist beliefs (Rimm-Kaufman et al., 2006), and then rely on teacher-directed instruction the first few years of teaching (Hong, 2010). Another pivot seems to occur after educators gain more experience, (Cady et al., 2006) further indicating that honing one's teaching skills is a continuous process.

Barriers to technology integration

Simply holding a particular perception of technology integration does not ensure it will occur in actual practice (Fives & Buehl, 2012). In a large-scale study, Hutchison and Reinking (2011) found a significant disparity between how literacy teachers perceived technology's value in student learning and the frequency in which they utilized digital tools to engage students in ways that reflected "a stance that views ICTs as integral to the curriculum" (p. 314). Although technology has become more valued in education, why is there such a gap?

In 2007, Hew and Brush found the two most commonly cited barriers impacting technology integration were resources and teachers' technology skills. These barriers still exist more than a decade later (Kuhfeld et al., 2020), compounded by additional factors such as time limitations, lack of administrative support, and the absence of professional development in how to design lessons that build students' complex higher-level skills (PwC, 2018). Additionally, a recent study by Francom suggests barriers differ in professional settings and become more or less challenging over time. In his study of 1906 K-12 public school employees in a north midwestern US state, Francom (2020) found large, suburban districts had less access to devices and technological resources than smaller, rural districts.

Developing TPACK

Building from Shulman's work (1987) on pedagogical content knowledge, Koehler and Mishra (2009) posited that separately and synergistically developing PSTs' knowledge of content (CK), pedagogy (PK), and technology (TK) would prepare them to transform these separate constructs into one distinct entity named technological pedagogical content knowledge (TPACK), a flexible body of knowledge that informs the effective application of context-specific technology-integrated teaching (Koehler & Mishra, 2009). TK refers to knowledge and proficiency with technology tools. CK refers to subject matter expertise as well as the ability to identify content-specific learning goals. PK refers to the theoretical and methodological knowledge needed to develop appropriate instruction. When these three core domains merge, they result in four additional constructs. Pedagogical content knowledge (PCK) reflects the understanding that content must be represented in ways that is comprehensible to others (Shulman, 1986). Technological content knowledge (TCK) refers to understanding that content goals can be supported by digital tools. Technological pedagogical knowledge (TPK) is knowing how technology can be leveraged to influence teaching and learning given its affordances and constraints.

A review of the literature reveals different approaches to developing TPACK within teacher education settings (Koehler et al., 2014). One is to build PCK through methods courses and field experiences without integrating technology. Once PSTs are knowledgeable of content and pedagogy related to their field of study, digital tools are introduced. A second approach supports PSTs' transition from TPK to TPACK by offering stand-alone technology courses that focus on functional skills associated with digital tools and general pedagogical strategies for their implementation. Stand-alone courses offered early in education programs can provide PST with opportunities to reflect on their beliefs about technology integration when confronted with concrete content-specific examples along with general discussions on pedagogy (Funkhouser & Mouza, 2013). Research indicates, however, that substantial change to PSTs' beliefs will only occur within situated contexts where they can observe such practices first-hand (Mouza, 2009; Mouza et al., 2017)

This leads to a third approach which develops PSTs' PCK and TPACK simultaneously when technology integration is embedded within content-area methods courses and field placements (e.g., Hur et al., 2010). The purpose of this holistic approach is to introduce and strengthen pedagogical decision-making in direct relation to content and technology use. Such opportunities have been found to increase PSTs' confidence in teaching with technology as well as the increase application of digital tools in lesson design and implementation (Buss et al., 2018; Mouza et al., 2017).

Research investigating TPACK development has illuminated at least three ways TPACK development strengthens PSTs' technology integration. First, a greater understanding of the interactions between the constructs has been found to bolster PSTs' self-efficacy (Joo et al., 2018). Second, TPACK has been found to positively influence PSTs' perception of the value technology adds to student learning (Joo et al., 2018). Thirdly, there is evidence that developing TPACK over the course of an entire teacher education program can improve technology-integrated lesson planning (Hofer & Grandgenett, 2012; Shinas et al., 2015).

However, we would be remiss to ignore the challenges associated with applying the TPACK framework in research and practice. As Graham (2011) notes, there are 'fuzzy boundaries" (p. 1953) between each TPACK domain, making it difficult to clearly identify if, when, and how they are reflected individually and combined in practice. The absence of an acceptable level of discriminant validity also influences the framework's usefulness in research by making it nearly impossible to predict outcomes (Archambault & Barnett, 2010). Additionally, much of the research investigating TPACK is collected through self-report data. In turn, participants' perceived knowledge of technology integration may not reflect actual implementation (Archambault & Crippen, 2009).

Background of current study

To alleviate some of the concerns described above, the research presented here extends previous studies (Mouza et al., 2017; Shinas et al., 2015) that employed mixed methods to closely examine the TPACK development of PST who completed the same K-8 teacher licensure program. PST took a one-credit survey course freshman year in an effort to develop TK. Over a six-week session they were introduced to a range of applications (apps), web authoring tools, electronic grade books, and Internet safety. During their junior year, PST were enrolled in a set of content area methods courses that included accompanying field experiences in local schools. The purpose of the methods courses was to build CK and PK in the specified discipline. The same semester, PST took a two-credit technology course. This course introduced TPACK and its domains and used the content and pedagogy learned in the methods courses and field experiences as context for practicing tech-integrated lesson design. Students created lessons for the classrooms they were placed in by selecting appropriate learning goals, matching pedagogical approaches to those goals (e.g., grouping), identifying appropriate activities and assessment strategies, and choosing technology tools they believed supported content.

To measure TPACK development, pre-post survey data were collected from 299 PST (Shinas et al., 2013) using the Survey of Preservice Teachers' Knowledge of Teaching and Technology, a measure of PSTs' knowledge across the seven TPACK domains (Schmidt et al., 2009). Results indicated that the technology preparation provided by the teacher licensure program demonstrated a statistically significant improvement on PSTs' TPACK development and the TK, PK, and TPK domains. (See Shinas et al., 2015 for more detail)

Although results from these studies were promising, it remained unknown if the PST would leverage their TPACK knowledge in their own instruction once they began their teaching careers. This next step is addressed in the current study.

Methods

This study was organized in three phases. Phase I was the administration of a survey to collect data related to three research questions:

1. What factors predict novice teachers' ICT integration?
2. Which ICT activities do novice teachers perceive as most important and to what extent are they integrated?
3. What are perceived obstacles to integration?

Phase II of the study consisted of examining in more depth the survey results by interviewing a subset of participants for the purpose of uncovering specific contexts and nuances that would further illuminate the survey findings. Thus, the interview protocol was developed after the survey data were analyzed. Phase III was the intentional integration of the quantitative and qualitative findings to understand more clearly the topic under study.

Participants

The participants of this study were K-8 teachers who completed their teacher licensure program at the same large mid-Atlantic university. Since it was unknown how many former students were employed in K-8 schools as classroom teachers, an email invitation was sent to all 282 graduates in the university's database of graduates within the recent two-year period. A total of 57 participants completed the survey, yielding a 20% return rate. Of the 57 responses collected, 7 were incomplete. These were removed from the data set, leaving a sample of 50.

Survey participants were between the ages of 22 and 25 years old. The majority were female (n = 46), taught in mid-Atlantic states with one teacher working overseas; on average, they reported 1½ years of teaching experience. They taught a range of grade levels: K-3 (n = 24), 4–5 (n = 10), and 6–8 (n = 16), with 11 working in special education settings and two working directly with English Language Learners. Important for the purposes of this study, 44 participants used technology daily as part of their instruction. A majority of teachers had access to Internet-connected computers in the classroom (n = 46), digital projectors (n = 37), interactive whiteboards (n = 35), and document cameras (n = 27). Less than half the participants reported access to laptops for each student (n = 13), digital video recording equipment (n = 10), tablets (n = 15), student email (n = 2), and e-readers (n = 1). Teachers reported receiving mostly technical support from district (68%) and in-school (50%) technology coordinators when compared to instructional support from the same coordinators (28%, 22%). Most technical and instructional support came from library/media specialists (74%).

Participants were invited to share their email if they were willing to discuss their perceptions of technology integration further with the researchers. A total of 20 participants included their contact information and were subsequently interviewed in Phase II of the study. Participants in this phase taught a range of grade levels in one of four mid-Atlantic states. Table 1 provides demographic information and a listing of pseudonyms.

Phase I: Survey data collection and analysis

Survey data were collected using *The Survey of Technology Use in Literacy and Language Arts* (Hutchison & Reinking, 2011). This self-report instrument consisted of 88 items, including Likert scale (0–3 scale), multiple choice, and open-ended questions. The initial survey was informed by the literature on survey development and research on technology in education (e.g., Dillman, 2007; Ertmer & Ottenbreit-Leftwich, 2010). An initial pool of survey items was developed and a focus group of teachers was consulted to gauge the appropriateness of the measure (Hutchison & Reinking, 2011). Analyses were conducted on the items hypothesized to represent the con-structs used to design the survey. Cronbach's α which determine how items reliably measure the same constructs ranged from .82 to .96 (Hutchison & Reinking, 2011).

Designed to examine teachers' knowledge and perspectives regarding technology, the survey was chosen for two reasons. First, it was informed, in part, by TPACK (Koehler & Mishra, 2009). Hutchison and Reinking (2011) explained, "We developed the survey to distinguish between what we refer to broadly as technological integration and curricular integration" (p. 314). The latter reflected the synergy between content, pedagogical, and technology knowledge, resulting in dynamic learning opportunities that "view ICTs as integral to the curriculum" (p. 314). Technological integration, however, was characterized by a focus on technology tools and

Table 1. Participants in Phase II of study.

Pseudonym	Grade	Subject	Experience	Gender
Riley	K	ELA	1½ years	Female
Gabi	1	ELA and Math	1 year	Female
Laura	1	ELA and Math	1 year	Female
Gloria	1	ELA and Math	1 year	Female
Kristina	1	ELA and Math	3 years	Female
Marcia	2	Social Studies	2 years	Female
Shawna	2	ELA and Math	1 year	Female
Fran	2	ELA	1½ years	Female
Randi	4–5	Math	1 year	Female
Harriet	4	Math	1 year	Female
Sindy	4	ELA	1½ years	Female
Hope	5	Math	1 year	Female
Sari	5	Social Studies	1½ years	Female
Bonnie	6	ELA	1 year	Female
Scott	6	Math	1½ years	Male
Marnie	7	Science	1½ years	Female
Charlie	8	Science	3 years	Male
Gerri	8	Math	1½ years	Female
Arielle	6–8	ELA	2 years	Female
Perry	6–8	ELA	1 year	Male

the functional skills associated with them. Second, Hutchison and Reinking (2011) suggested their work be considered "a broad backdrop to inform more narrowly focused studies in the future" (p. 331). They administered the original survey to anonymous teachers with little information known about their technology preparation or ongoing professional development. The study described here focused on a particular population, novice teachers who developed TPACK by participating in the same teacher licensure program (Shinas et al., 2015).

For the purposes of this study, we removed the terms "literacy/reading" from the original survey questions. We approached this work with a broad definition of literacy, one that encompassed the ability to read, write, listen, and speak in all content areas (Hong, 2010). We were interested in exploring perceptions of integrating technology within a different population than that of the original authors of the survey. We were also concerned novice teachers, mainly the content area educators, may be confused if asked to respond to questions focused solely on literacy/reading instruction.

Data were collected using an online survey program. Data were exported from the online survey tool into a spreadsheet and blinded and then imported into SPSS and screened to identify outliers. Analysis followed based upon the research questions and procedures described in the findings section below.

Open-ended response data were analyzed using a priori codes developed by Hutchison and Reinking (2011) as well as codes that labeled instances of TPACK, both individual domains and as a synergistic frame. This analysis was followed by open coding to label codes that were not represented in the initial scheme (Strauss & Corbin, 1990). To ensure a common approach to coding and analysis, we coded 10 open-ended responses together. Next, the remaining responses were coded independently and findings were compared. All disagreements were discussed until agreement was reached.

Phase II: Qualitative data collection and analysis phase

To further examine quantitative results, individual semi-structured phone interviews were con-ducted in Phase 2. Interview protocols were framed by the survey data so certain variables could be further examined to determine their contribution to technology integration. In addition to responding to interview questions, participants were invited to provide at least one technology integrated lesson plan and describe its learning goals and whether they felt the lesson was successful.

The interviews were transcribed verbatim. Next, we conducted independent multiple readings of all Phase II data sources and created a table that documented all technology-integrated activities that were described. We then reviewed the tech-integrated activities in conjunction with the other insights shared in the interviews in an effort to provide context and make connections between the qualitative data. We analyzed these responses in relation to the lesson plans they shared with us, looking for confirmation or lack thereof. We also analyzed the data deductively (Patton, 2015) to identify instances of if and how the TPACK domains (i.e., content, pedagogy, and technology) were separately and/or synergistically reflected in how teachers self-reported their technology integration.

Phase III: Integration of qualitative and quantitative results

Integration in an explanatory sequential design involves merging the quantitative with the qual-itative results to determine how they are more informative as a collective rather than in isolation (Creswell & Clark, 2018). This phase followed a three-step process. First, we reported in narrative form the quantitative results. Second, we reported in narrative form the qualitative results. Third, we placed the major findings in a joint display, a visual representation of the integration of quantitative and qualitative findings in relation to the survey's research questions. This presen-tation allowed for side-by-side comparisons in an effort to generate inferences that described the overall findings as confirmed, expanded, or discordant.

Phase I results

What factors predict novice teachers' ICT integration?

Hutchison and Reinking (2011) found five factors that affected the technology integration of a general population of teachers: competency, stance, availability, obstacles, and perceived importance (see Hutchison & Reinking, 2011 for representative items of each). In this study, a direct-entry (standard) MRA (Tabachnick & Fidell, 2018) was conducted using these factors to determine which, if any, affected NTs' integration. The direct-entry approach is appropriate when all factors are entered simultaneously, as there was no specific hypothesis for which variables may be important. Distributional statistics (means, standard deviations) for the predictors and criterion are presented in Table 2 as well as the univariate correlations. The bivariate associations reveal a positive relationship between Perceived Importance and Integration (r = .65, p<.05), Competency and Integration (r = .25, p<.05), and Stance and Integration (r = .29, p<.05).

Results from the MRA revealed that the overall model was statistically significant and explained 47% of the novice teachers' integration of ICT, (F (6, 43) = 6.25, p < .001, f^2=. 89). However, only perceived importance made a statistically significant, unique contribution to the integration of ICT (β=. 61, t (50) =4.9, p< .001)while competency, stance, availability, and obstacles did not. In sum, these results suggest that, perceived importance of ICT is the only significant predictor of novice teachers' integration (see Table 3). *p < .05.

Which ICT activities are perceived as most important and to what extent are they integrated?

Understanding how important novice teachers perceived ICT activities would provide further insight into how their perceptions predicted their integration. Participants were asked to indicate on the survey the extent to which they engaged students in activities that required necessary skills and strategies for 21st century reading and writing (Leu et al., 2013). Additionally, they were asked to indicate the importance of integrating each activity.Survey participants reported that locating information online (M = 2.00, SD = 1.07), playing educational games online (M = 1.98,

Table 2. Means, standard deviations, and bivariate correlations for the predictor variables in the model: (1) competency with ICT, (2) stance toward technology, (3) availability of technology, (4) obstacles to integration, (5) perceived importance of ICT, and (6) integration of ICT.

Variable	*M(SD)*	1	2	3	4	5	6
1. Competency	6.92(1.32)	1	.33*	.21	−.08	.21	.25*
2. Stance	4.04(.81)	.33*	1	.43*	−.15	.25*	.29*
3. Availability	5.66(2.17)	.21	.43*	1	−.13	.03	.18
4. Obstacles	6.64(3.52)	−.08	−.15	−.13	1	.21	.15
5. Perceived Importance	26.72(11.99)	.21	.25*	.03	.21	1	.65*
6. Integration	11(7.83)	.25*	.29*	.18	.15	.65*	1

Note. *$p < .05$

Table 3. Regression analysis summary for competency with ICT, stance toward technology, availability of technology, obstacles to integration, perceived importance of ICT.

Variable	*M(SD)*	*B*	β
Competency with ICT	6.92(1.32)	.45	.08
Stance toward technology	4.04(.81)	.78	.08
Availability of technology	5.66(2.17)	.58	.16
Obstacles to integration	6.64(3.52)	.13	.06
Perceived importance of ICT	26.72(11.99)	.34*	.61*
Constant	–	−8.79	–

Note. R^2 = .47 (N=50, p = .000) f^2 = .89, Cohen's (1988) effect size statistic for multiple regression analyses. * $p < .05$.

SD=. 94), creating a multimedia presentation (*M* = 1.94, *SD* = 1.06), searching for information online (*M* = 1.94, *SD* = 1.1), and creating a word document (*M* = 1.84, *SD* = 1.08) were most important. The least important instructional activities were writing opportunities via online publishing (i.e., websites, blogs, wikis), real-time chats, and email conversations (see Table 4). Playing educational games, reading a book online, and locating information online were rated the most frequently integrated ICT activities.

The differences were then calculated between the mean values for reported importance and frequency for each activity. Like Hutchison and Reinking (2011), this analysis yielded negative values for every ICT activity, thus revealing a gap. To further study these discrepancies, a paired-samples t-test was conducted to determine if there was a significant difference between the extent of teachers' integration and their perceived importance (Chai et al., 2010). Analysis revealed a statistically significant difference between teachers' integration and perceived importance for all activities except one: playing educational games online. These findings suggest that teachers' perceived importance of most ICTs is rated higher than the frequency of their integration of these activities.

What are perceived barriers to technology integration?

Despite how important teachers consider the ICT activities, survey results indicated a discrepancy between importance of integrating ICT activities and the actual integration of them. To examine why teachers may not integrate technology, they were asked to indicate on the survey the extent to which they believed a set of barriers impeded their technology integration. Table 5 presents the barriers in order of most challenging to least.

The most common barriers were external, meaning outside of the NTs' control. For example, lack of time during class (1.94), lack of access to technology (1.86), and lack of professional development on how to integrate technology (1.86). NTs' skills and beliefs related to technology integration were reported as the least challenging barriers: not knowing how to use technology (.18), thinking technology does not fit my beliefs about learning (.08), and thinking technology integration is not useful (.04).

Table 4. Means, standard deviations, and distributional statistics for ICT reported frequency and perceived important of ICT.

	Locating information online	Playing educational games online	Creating a multimodal presentation	Searching for information online	Creating a Word document	Reading a book online	Using reference sites online	Using specific search strategies to search for information online	Evaluating information online
Perception of importance M (SD)	2(1.07)	1.98(.94)	1.94(1.06)	1.94(1.1)	1.84(1.08)	1.74(1.05)	1.7(1.13)	1.7(1.1)	1.64(1.12)
Reported frequency M (SD)	.96(.88)	1.82(1.1)	.62(.88)	.82(.94)	.94(1.02)	1.12(1.17)	.72(.81)	.56(.73)	.54(.79)
Difference between frequency and importance M (SD)	−1.04(.88)	−.16 (.77)	−1.32(.94)	−1.12(.94)	−.9(.91)	−.62(.86)	−.98(.96)	−1.14(.86)	−1.1(.89)
t	−8.36	−1.48	−9.98	−8.43	−7	−5.13	−7.23	−9.4	−8.78
P value	.000	.15	.000	.000	.000	.000	.000	.000	.000
d	1.06	.16	1.3	1.1	.88	.56	1	1.22	1.18
	Formulating questions to research online	Synthesizing information online	Gathering pictures online	Collaborating online with students from other classes	Sending email	Playing ed games on a CD-ROM	Publishing information on a wiki or blog	Publishing information on a website	Communicating using instant messenger or other chat tools
Perception of importance M (SD)	1.6(1.09)	1.48(1.15)	1.38(.99)	1.2(.97)	1.14(1.01)	1.1(.97)	.96(.88)	.82(.87)	.56(.76)
Reported frequency M (SD)	.42(.61)	.52(.74)	.68(.77)	.12(.33)	.32 (.79)	.48(.93)	.16(.47)	.12(.44)	.08(.27)
Difference between frequency and importance M (SD)	−1.18(.92)	−.96(.9)	−.7(1)	−1.08(.92)	−.82(.83)	−.62(.88)	−.8(.88)	−.7(.79)	−.48(.71)
t	−9.1	−7.52	−4.98	−8.3	−7.02	−4.9	−6.42	−6.27	−4.8
P value	.000	.000	.000	.000	.000	.000	.000	.000	.000
d	1.33	.99	.80	1.5	.9	.65	1.13	1.02	.84

Note. N = 50.

Table 5. Means and standard deviations of responses concerning perceived barriers to integrating ICTs into instruction.

Potential obstacle	*M*	*SD*
Lack of time during a class period	1.94	1.05
Lack of access to technology	1.86	1.14
Lack of professional development on how to integrate technology	1.16	.97
Difficulty controlling what information students access online	1.16	.86
Lack of technical support	1.12	1.02
Internet text seemingly too difficult for students to read	1.04	.80
Not knowing how to evaluate or assess students when they work online	.90	.83
Not knowing how skills students are at using technology	.86	.85
Considering technology to be unreliable	.80	.78
Lack of time to integrate technology because of the amount of time required to prepare students for high stake testing	.78	.86
Lack of incentives to use technology	.76	.91
Lack of support from administrators	.72	.97
Difficulty managing the classroom when students are working on computers	.64	.82
Not knowing how to incorporate technology and still teach content standards	.56	.67
Lack of understanding of copyright issues	.50	.73
Lack of understanding of how to integrate technology into literacy instruction	.40	.60
Not knowing how to use technology	.18	.43
Thinking that technology doesn't fit my beliefs about learning	.08	.27
Thinking that technology integration isn't useful	.04	.19

Phase II findings

Novice teachers' perceptions of technology importance and integration

Because the survey results indicated that perceived importance of ICT was a significant predictor of NTs' technology integration, we aimed to learn more about participants' perceptions of technology integration. We approached this by asking questions during the interviews such as, "Do you think technology integration is important to student learning?" and "What does it look like to integrate technology into your teaching?"

Overall, the qualitative analysis confirmed the survey results. Interview responses included statements such as "Yes. I believe in having technology be a routine part of instruction, not only if you have time, but as a way to teach students" and "I think it is important as long as technology is paired along with instruction and incorporated into it…not separate." However, although they agreed technology integration was important, what integration looked like was perceived differently by the participants.

A total of three participants described their use of ICT in terms of technological integration, meaning a strategy to enhance conventional teaching. For example, Marnie, a seventh-grade science teacher, shared a technology-integrated lesson where students used digital thermometers that could measure temperature changes in liquid and then automatically graph the data on the students' computers. She used the tool as a substitute for a traditional thermometer because it saved time during her 45-minute class sessions, freeing students to "spend more time analyzing and interpreting the graph, which was the whole goal of the lesson."

Similarly, Scott, a sixth-grade math teacher, explained how document cameras, Power Point, and interactive whiteboards could serve as delivery mechanisms in ways that would "allow for a whole group presentation with manipulatives to be seen up close by all students." Again, this perception reflected technological integration because the ICTs were viewed as merely presentation tools rather than opportunities to transform curriculum.

These perceptions also focused on the functional skills associated with technology, describing integration as "basic typing skills, how to navigate a website and folders on a computer." Participants spoke about the time they invested in preparing students to use the computer and other digital tools. Arielle, a middle school English and Language Arts teacher, explained, "I feel like half my job is teaching the kids how to use the computer… they know how to use social media… but they don't use computers for academic reasons." Again, her perceptions emphasized her reliance on technological knowledge (TK), with little mention of how pedagogical knowledge (PK), content knowledge (CK), or the potential synergy between all three TPACK constructs could support students' understanding of the learning goal while strengthening their technology skills.

In contrast, the majority of participants (n = 17) talked about their design of technology integrated instruction in terms that reflected more than one TPACK domain. For instance, one theme was providing opportunities for students to serve as both active producers and consumers of information rather than passive recipients of teacher-directed instruction. When describing the process of designing this type of instruction, participants discussed how they matched instructional activities to curriculum standards (CK) and student skills (PK) and then identified appropriate digital and non-digital resources and tools to support student learning (TK). Sindy, a fourth-grade teacher, described a multistep lesson she created to teach two learning goals: (1) conduct short research projects that build knowledge through investigation of different aspects of a topic and (2) write informative/explanatory texts to examine a topic and convey ideas and information clearly. After self-selecting a country to study, students used a combination of digital and non-digital resources to research information to present in an informational text. Students then produced their writing on a classroom blog and shared their posts with classmates to begin a conversation about their chosen topic. The technology (blog) was leveraged to perpetuate a conversation between classmates that included posing questions and commenting on the information shared. Sindy believed this lesson reflected successful technology integration because of the interaction it afforded them and students met the learning outcomes by successfully locating relevant information and synthesizing it in ways that "demonstrated they were able to write to inform others."

Another example came from Sari, a fifth-grade social studies teacher. Her lesson targeted two standards: (1) how geography affected different battles in the Revolutionary War and (2) recognizing multiple perspectives and biased views in texts. She assigned her students a digital interactive map of Paul Revere's ride to warn the revolutionaries that the British were on their way as well as a second text that was a traditionally-printed written version of Henry Wadsworth Longfellow's poem, *Paul Revere's Ride* (1861). Sari explained she selected the map so students could leverage its multimodality by revisiting each step of his ride as they analyzed the poem. "Using technology helped them to see exactly what was happening minute by minute and they could go back and forth [between the texts] to figure out the historical inaccuracies in the poem." After their analysis, students used Google Docs to collaborate on a letter to Longfellow explaining how his poem was "historically inaccurate and how he was teaching kids the wrong information."

A second theme was the way elementary teachers used their TPACK to organize instruction to meet student skill levels. Learning stations is a model where students rotate through a series of digital and non-digital activities designed to meet the same learning goals, but differentiated by content, product, or process (Tucker, 2020). Importantly, one of the stations is teacher-led which provides time for teachers to meet with small groups or individual students to model, answer questions, or provide feedback.

When describing her technology integration, Randi, an elementary math teacher, relied heavily on stations because "I work with students in special education and I would not be able to meet the needs of all the kids in my class if I didn't use small groups." Her instructional design followed a similar routine each day of introducing a math concept to the whole class, modeling problem solving strategies, and then assigning students to stations they would rotate through

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to practice independently, with partners, or with her. Some stations incorporated technology, specifically iPads, and others used non-digital manipulatives. Randi explained that she liked using the iPads for stations because of the scaffolds the math applications incorporated. For example, when describing a digital math game serving as one of her stations, she said "what the technology does is light up the next place in long division where the student had to write the number." The game also alerted students if their answers were incorrect and provided support for solving the problem. She felt these types of scaffolds were critical to the success of her stations because they provided just enough support to her students that she was free to direct her attention to her small group.

What are perceived barriers to technology integration?

Changing technologies

Participants described digital tools as 'moving targets,' referencing how quickly new technologies are introduced which requires them to stay current. Participants talked about this in relation to their technology preparation, noting discrepancies in the types of technology tools utilized in their undergraduate program and those available in their current classroom setting. As one participant explained, "I think we were definitely encouraged to use technology but because its changing so rapidly… I didn't have a lot of preparation in the types of technology I'm using [now]." For example, Fran, a special education teacher, stated in her interview:

When I was in college, I learned how to implement laptops and other tools, mostly websites. But when I started teaching, the school handed me an iPad with no training. I want to do fun activities with my students, but I don't know how.

Access

When asked during the interviews what would support their technology integration, all participants asked for more access to ICT. This view was initially unexpected given the teachers' reports of the types of technology available in their schools. For example, almost all reported Internet connected computers in the classroom and many had access to digital projectors, digital cameras, and interactive whiteboards. However, upon closer examination, the types of ICT reported facilitated teacher instructional use in whole group configurations rather than access that would foster individual or small group student engagement, one of the ways in which they defined technology integration. For example, Gabi reported a high desire to increase her technology integration but reported access issues inhibited her ability to do so. She explained,

> The reading curriculum comes with a disk that has lessons for the SMART Board. I used this when I was student teaching as a supplement to the lesson because it added an interactive component. If we were learning about vowels there would be a game that corresponded to the focus lesson. However, since I don't have a SMART Board now, I can't use the disk.

Professional development

Survey data indicated participants felt competent in the functional skills associated with technology integration, but were challenged by the actual integration of technology in meaningful ways. This finding was elaborated upon during the interviews revealing two critical professional development (PD) needs. First, teachers wanted PD that elevated their understanding of using digital tools to teach their curricula to diverse groups of students. Second, they wanted PD that focused on the technology readily available to them. As Perry explained, "Often we are trained in [technology] tools that we don't have access to or that don't seem to fit with the content we're required to teach. It would be more helpful to have training that shows us what it can look like in our actual classrooms."

Discussion

Below we present Phase III of this study, which was the integration of data, where we share expanded and discordant findings. potential interpretations, and practical implications.

First, the quantitative results suggest participants perceived ICT as important to their teaching, in turn, contributing to their technology integration. The qualitative results not only confirmed this finding, but expanded it by highlighting the types of knowledge teachers tapped into when designing activities. A small set relied mainly on their knowledge and proficiency with digital tools (TK). The majority, however, drew upon their pedagogical decision-making (PK) and content knowledge (CK) in combination with their technological knowledge to create effective applications of content-specific technology-integrated teaching (TPACK). These results run contrary to larger scale studies that found most teachers conceptualize integration as supplements to traditional classroom instruction (Hutchison & Reinking, 2011; Pang et al., 2015). One explanation may be the participants' positive beliefs about technology integration coupled with the TPACK knowledge developed during their preservice teacher program led them to envision technology-integrated lesson design as central to schooling. Thus, this study demonstrates how TPACK-framed teacher education may influence novice teachers' use of technology in their own classrooms.

The quantitative analysis also identified a statistically significant difference between the teachers' perceived importance of technology-integrated activities and their actual integration. For example, locating and searching for information online and creating multimodal presentations were perceived as some of the most important activities, yet on the survey teachers reported not incorporating them frequently. These results mirror Hutchison and Reinking (2011) survey findings. The qualitative results from this study, however, diverge from this finding when analyzing the types of activities participants reportedly incorporated into their instruction. Sindy's fourth graders researched countries on the Internet, used word processing tools to write essays, and published their multimodal work to discuss with others on a classroom blog. Sari's students leveraged the multimodal affordances of digital and non-digital resources to seamlessly compare and contrast the content and form judgements about their accuracy. Additionally, elementary teachers shared lessons that illustrated how the multimodal affordances of technology were leveraged to differentiate instruction. These examples illustrated approaches to engaging students in transformative instruction, meaning lessons that leveraged the affordances of technology to support student learning (Beach & O'Brien, 2015). Furthermore, they characterized their tech-integrated instruction in ways that required students to actively participate in both the consumption and production of information.

One explanation for the discordant findings may be the survey design. Frequency was reported using a 4-point scale: not at all (0), a small extent (1), a moderate extent (2), and a large extent (3). Results could be dependent upon participants' views of the distinctions between these ratings and although those who were interviewed reported use of many of those listed, perhaps they did not feel they did so frequently enough. Another explanation may be the participants defined their activities differently than how they were presented on the survey. The lesson plans shared by the teachers included instructional chains that reflected the synergy between TPACK domains not isolated activities as they were presented on the survey. This finding supports existing literature on TPACK-framed technology preparation (Buss et al., 2018; Shinas et al., 2015) that demonstrates the positive impact of a holistic approach that builds pedagogical knowledge simultaneous to strengthening content and technology knowledge.

Third, the quantitative results suggest a variety of barriers prohibited the full extent of participants' technology integration. External factors, such as time constraints and accessibility, were the most challenging. Teachers' beliefs about technology as well as their views of their own skill set were the least challenging. The qualitative findings confirmed these results, but also expanded upon them. It seems the ever-changing nature of technology challenged the teachers to stay up to date on the most recent tools and their functionalities. They spoke about how the tools covered in their teacher preparation programs were outdated by the time they entered the classroom. Or, in some cases, their professional settings were not equipped with the same tools making their prior knowledge obsolete. This barrier highlights the importance of preparing educators to not simply learn a tool, but instead examine learning objectives in conjunction with what they know about student needs before selecting appropriate technology (or not) to support instruction. Although their teacher preparation program was framed in this way, it seems there may have been an overreliance on particular tools.

Limitations and future directions

Although this study gleaned important findings related to novice teachers' perceptions of ICT integration, the limitations must be considered. First, data were collected using self-report measures. Second, although the survey included open-ended questions that provided teachers with opportunities to express their views, interviews with more teachers than the 20 who participated would yield richer insights into their perceptions of ICT. Third, because the study was limited to participants who had completed the same teacher preparation program, the sample was relatively small, making generalizability a challenge. That said, the use of both qualitative and quantitative data along with the ability to contextualize the novice teachers' responses in relation to their teacher preparation program provides a longitudinal view of if and how teachers with developed TPACK utilize technology their first years in the profession.

Perhaps the most critical finding for teacher licensure programs and researchers in the field to examine in more depth is that although participants perceived technology integration as important, it seems TPACK did not prepare them to overcome persistent barriers (Hew & Brush, 2007; Kuhfeld et al., 2020). How then might teacher licensure programs better prepare PST to pivot their practice when confronted with such obstacles? We suggest embedding opportunities for PST to problem-solve challenges they may encounter in their future professional settings. This can be done through case-based instruction (Shulman, 1986), a pedagogical approach that envelopes candidates in situated learning. They can work individually or with classmates to identify solutions to hypothetical technology-related problems or ones they have observed in their student teaching placements (Koehler et al., 2019). Moreover, programs can work in tandem with school districts to support novice teachers through mentoring, new teacher seminars, and additional planning time. These opportunities are currently offered in many schools, but research indicates just providing them to new teachers is not sufficient, the quality of such offerings is what makes the difference (Ronfeldt & McQueen, 2017).

Another direction to explore would be to support PST and new teachers by scaffolding collaboration and leadership skills so they can seek out or initiate professional learning communities with the goal of tackling obstacles impeding effective technology integration. The changing instructional landscape precipitated by increased access to sophisticated digital technologies requires all teachers to be "perpetual novices" (Mueller et al., 2008, p. 1524) who are continuously searching for ways to strengthen their instruction. One strategy is to teach novices to build digital professional learning networks (PLN), connections made over social media platforms that can enrich their professional practice by providing spaces to ask questions, brainstorm, vent, and share resources with a global community. A recent study of 258 teachers' perceptions of online professional development (Parsons et al., 2019) indicated benefits of such PD, including 24/7 access, real-time solutions to problems, and access to resources not otherwise available. Further investigation into how to expand such professional development opportunities could prove useful.

Conclusion

The Covid-19 pandemic had not yet occurred when we collected or analyzed data for this study. Since then, the educational landscape has changed dramatically and schools and educators dis-played their ability to adapt to enormous shifts in teaching and learning. A majority of schools are now equipped with digital devices, in many instances one for each student (Bushweller, 2020). Administrators have worked hard to find ways to support their teachers' design of technology-integrated instruction (Harris & Jones, 2020). And, educators learned to utilize technology in ways they may not have previously imagined. Developing TPACK is one way to support teachers' technology-integration. Yet, the complexities associated with technology integration require teacher licensure programs to also equip them with the tools to problem-solve when confronted by unforeseen challenges.

Notes on contributors

Rachel Karchmer-Klein is an Associate Professor in the School of Education at the University of Delaware. Her research interests focus on the intersection of literacy and technology, with an emphasis on practical implications for K-12 instruction.

Haruka Konishi is an Assistant Professor in the Department of Education at Missouri Western State University. She studies early childhood education and the link between language and self-regulation.

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