A Longitudinal Qualitative Study on Teachers' Technology Barriers to Distance Learning: A School for Students with Dyslexia

Holli Bice
University of South Carolina, U.S.A.

Hengtao Tang
University of South Carolina, U.S.A.

Abstract: *The purpose of this qualitative case study was to develop an account of teachers' perception of barriers to technology integration throughout distance learning. The COVID-19 pandemic forced schools to adopt distance learning to cope with the crisis, but what remains unknown was whether teachers were prepared for this change. Therefore, this study described teachers' experience of technology integration over the course of distance learning and identified the barriers they faced at a small, private school for students with dyslexia. The findings revealed that distance learning influenced teachers' technological knowledge, attitudes, and beliefs about technology integration. All participants identified barriers to technology integration. Novice integrators and one intermediate integrator experiencing second-order barriers, which were their lack of technological knowledge and beliefs about technology. Implications are provided for supporting teachers to overcome barriers towards technology integration.*

Keywords: teachers, technology integration, barriers, dyslexia, distance learning

Introduction

In response to the disruption by the COVID-19 pandemic, K-12 schools have chosen distance learning to continue teaching and learning. Online instruction depends on extensive use of technology as technology serves as the vehicle to connect with their students, whether synchronously or asynchronously (Greer et al., 2019). To accomplish these tasks, online teachers must be skilled in basic uses of technology (Kwon et al., 2019; Tang et al., 2016). However, whether K-12 teachers are ready for effective technology integration for remote teaching is unknown.

Despite the increase in technology available, teachers at schools exhibited this discord between access and use. Research has shown that teachers used technology tools to sustain already established teaching practices such as drill and practice activities or displaying information (Pittman & Gaines, 2015). Even teachers in online courses are found to assign students seat work for asynchronous assignments that practice knowledge or skills presented during the lesson (Choudhury & Pattnaik, 2020).

Teachers are not using technology in ways that enhance learning due to numerous barriers (Blackwell et al., 2013; Ertmer, 1999; Francom, 2016; Hew & Brush, 2007; Pittman & Gaines, 2015). Such barriers to integration are defined as "existing conditions that render the successful implementation of [information and communication technologies] in educational settings difficult to achieve" (Makki et al., 2018, p. 91). Researchers have separated these barriers into two categories: first-order and second-order barriers (Blackwell et al., 2013; Ertmer, 1999). First-order barriers consist of more extrinsic resources such as lack of access to technology, lack of time to plan or implement, and inadequate technical support (Ertmer, 1999; Makki et al., 2018). In contrast, second-order barriers are those more intrinsic to teachers and address teaching beliefs, beliefs about computers, established classroom practices, and unwillingness to change (Bice & Tang, 2022; Ertmer, 1999). As technology becomes more available in schools, it appears second-order barriers play a significant role in technology integration (Blackwell et al., 2013; Ertmer et al., 2012). In fact, Ertmer (1999) suggested second-order barriers were more difficult to change and required teachers to redefine what teaching meant to them.

Barriers that inhibit successful technology integration vary by time and contexts, thus developing a longitudinal account of teachers' barriers about technology integration is needed (Xie et al., 2021). Distance learning experience during the pandemic has changed teachers' perception towards technology in their teaching practices, but little is known about how teachers' perceptions of those barriers vary over this period. Therefore, the purpose of this study is to investigate teachers' barriers to technology integration across three time points during the course of distance learning. Such an understanding may inform effective strategies to support teachers in overcoming barriers and using technology effectively in the post-pandemic era.

Literature Review

Online Learning and Technology Integration

The National Education Technology Plan (NETP) specifies technology should be used to provide transformative learning experiences that equip students with 21st century skills to be competitive and engaged participants in a

global society (U.S. Department of Education, 2017). Primary and secondary schools have experienced significant increases in the amount of technology available with most schools now striving for a one device per one student ratio (Tondeur et al., 2018). In addition to increased technology within schools, school districts have begun leveraging technology to provide online learning opportunities for K-12 students (Greer et al., 2019).

Online learning is an "online, internet-based or web-based distance education program available to K-12 schools and students" (Greer et al., 2019, p. 404). Online instruction requires teachers to use different skills than those used for face-to-face instruction (Kwon et al., 2019). Archambault and Larson (2015) identified characteristics of effective online teachers as self-motivated, valued learning and education, and enjoyed the challenge and process of using technology for instruction.

Teaching online places technological demands on the teacher. Therefore, teachers need to possess strong technological skills in order to present content through technology (Choudhury & Pattnaik, 2020; Yang et al., 2022). They must possess basic skills relating to technology but also continue to expand their technological knowledge by exploring new technologies for the virtual environment (Kwon et al., 2019; Read et al., 2020). Teachers need to have the skills and knowledge to tackle hardware and software issues when they arise (Kayaduman & Demirel, 2019). Effective communication is also essential in online learning. Teachers need to be able to communicate across many different platforms such as discussion boards, email, and video chat (Archambault & Larson, 2015). Instead of pre-service training, many teachers are learning how to teach online while on the job or through professional development (Choudhury & Pattnaik, 2020; Schroth et al., 2019). However, many teacher professional development programs do not prepare teachers for online instruction.

Factors Affecting Technology Integration

Technology integration is a complex process involving many factors that can affect integration. This section explores factors that serve as (a) enablers of technology integration and (b) barriers to technology integration.

Enablers of technology integration

Teachers' knowledge and prior experience. Research indicates teachers' knowledge and experience with technology affect their decisions to integrate (Miranda & Russell, 2012; Petko, 2012). Specifically, teachers' prior experiences with technology and their competency in using technology impact integration (Miranda & Russell, 2012). Petko's (2012) study of teachers in Switzerland found computer competency to be one of five factors affecting the intensity with which teachers use technology. These findings suggest that when teachers know how to use technology tools effectively, they achieve higher levels of integration.

Teachers' attitudes toward technology. Research findings reveal attitude toward technology is a significant factor influencing integration (Coleman et al., 2016; Mueller et al., 2008; Pittman & Gaines, 2015; Tondeur et al., 2018; van Braak et al., 2004). Studies involving pre-service teachers (Tondeur et al., 2018) and practicing teachers (Coleman et al., 2016; van Braak et al., 2004) found attitudes toward technology positively impacted their use of technology in the classroom. Pittman and Gaines's (2015) survey of 75 primary school teachers concluded that the strongest correlation to technology integration

was teachers' attitudes toward technology. Additionally, a study of high integrators and low integrators determined attitudes toward technology to be one of the most distinguishing characteristics between the two groups (Mueller et al., 2008). Findings from these studies indicate that a positive attitude toward technology is one requirement for effective integration.

Teachers' beliefs about technology. Research into technology integration has identified teachers' personal beliefs as a factor affecting integration (Ertmer et al., 2006; McCulloch et al., 2018; Miranda & Russell, 2012; Petko, 2012; Vannatta & Fordham, 2004). Several studies have identified teachers' beliefs about the benefits of technology for student learning as one of the strongest predictors of use (McCulloch et al., 2018; Miranda & Russell, 2012; Petko, 2012). Vannatta and Fordham (2004) argued that teachers' philosophy and willingness to change were significant factors affecting integration. Technology teachers identified as exemplary technology users rated internal beliefs and commitment to student learning as the most influential factors guiding their technology use (Ertmer et al., 2006). Teachers' self-efficacy with technology has been found to be another significant predictor of technology use (Gu et al., 2013; Holden & Rada, 2011; Vareberg & Platt, 2018). It has been noted as a factor in pre-service teachers' intentions to adopt technology (Li et al., 2016) and practicing teachers' acceptance of technology (Holden & Rada, 2011). Additionally, the perceived usefulness and importance of technology for teaching have been recognized as one of the most significant factors affecting teachers' decisions to adopt technology (Vareberg & Platt, 2018).

Barriers to technology integration

Teachers may encounter factors that influence them to implement technology in their classrooms, but they may also encounter barriers that hinder technology integration. The following paragraphs examine (a) first-order barriers, (b) second-order barriers, and (c) overcoming barriers.

First-order barriers. Evidence of first-order barriers impacting technology integration is well-documented in the literature (Francom, 2016; Hew & Brush, 2007; Wachira & Keengwe, 2010). Not having access to technology or technology resources has been noted as a significant barrier to integration (Francom, 2016; Hew & Brush, 2007; Petko, 2012). Lack of access may occur when teachers share devices among classrooms or when technology is located in central locations such as lab settings or media centers. However, Hsu (2016) argued that access to technology was less of a barrier than teachers' knowledge and skills to implement technology, lack of time to plan, and lack of training. Other studies offer evidence to support these barriers. Teachers report not having time to plan lessons that incorporate technology prevents them from using it in their classrooms (Hew & Brush, 2007). Lack of training can inhibit technology use because teachers are not familiar with how to use the tools in the classroom (Francom, 2016). When teachers lack resources, such as technical support, they are deterred from using technology tools (Shifflet & Weilbacher, 2015). Support from leadership is also necessary for successful integration as findings reveal a lack of administrative support in schools hampers integration (Francom, 2016; Jones et al., 2017). Additional external barriers noted in the literature include students' technology ability (Hsu, 2016; Shifflet & Weilbacher, 2015) and assessment (An & Reigeluth, 2011). Teachers clearly encounter a variety of external obstacles that can hinder their efforts

to implement technology.

Second-order barriers. While first-order barriers still present challenges to integration, second-order barriers are also at play. Ertmer et al. (2012) noted the significant role of internal factors in helping shape classroom teachers' practices involving technology. For example, the knowledge and skills required to integrate technology can prevent teachers from using it in their classrooms (Hew & Brush, 2007; Hsu, 2016; Jones et al., 2017; Wachira & Keengwe, 2010). This includes knowledge of specific technology as well as ways technology can be used to support pedagogical practices. Teachers' fear of maintaining control in the classroom while using technology is another internal factor affecting integration (Hew & Brush, 2007; Vareberg & Platt, 2018). Perhaps the strongest internal barrier to integration is teachers' beliefs. The extant literature offers support that teachers' beliefs serve as a significant obstacle to integration (Gu et al., 2013; Hermans et al., 2008; Jones et al., 2017). Some studies have specifically noted that teachers' beliefs in their own abilities to use technology, or self-efficacy, is a hindrance (Jones et al., 2017; Li et al., 2016; Vareberg & Platt, 2018). Hew and Brush's (2007) meta-analysis of technology integration recognized teachers' attitudes and beliefs, especially the value teachers see in using technology for teaching and learning, to be a significant barrier. Vareberg and Platt's (2018) study provided support as teachers were reluctant to adopt technology when they did not see a clear purpose for using it. Second-order barriers may be less overt than first-order barriers, but they can impact effective technology integration.

Overcoming barriers. Teachers may encounter both first- and second-order barriers when trying to integrate technology. Despite these challenges, some teachers are able to overcome barriers to integration. Professional development is touted by many as a means to help teachers achieve technology integration (Ertmer, 1999; Ertmer et al., 2012; Hew & Brush, 2007; Kopcha, 2012). Several different approaches have been suggested such as communities of practice coupled with mentoring (Kopcha, 2012) and training focused on providing meaningful uses of technology (Ertmer, 1999). Hew and Brush (2007) suggested creating a shared vision and technology integration plan, reconsidering assessments, and changing attitudes and beliefs to address barriers to technology integration. Research findings offer some support for the suggestion of addressing teachers' beliefs as a way to overcome barriers. Walker and Shepard (2011) studied teachers who successfully integrated technology and determined they overcame barriers because they were motivated to deliver instruction and did not abandon lesson plans when technology failed. Similarly, Heath (2017) surmised teachers' positive beliefs toward technology and confidence in their ability to act as agents of change allowed them to overcome barriers. While these findings are encouraging, not all teachers have been able to overcome barriers to integration, even when they held positive beliefs about technology (Shifflet & Weilbacher, 2015).

Method

A qualitative case study (Creswell, 2014) was conducted to investigate teachers' experience with barriers to technology integration. This approach was selected because it allowed researchers to develop in-depth, holistic interpretations of a phenomenon and its context in natural settings (Yin, 2012). This case study explored the phenomenon of teachers experiences with integrating technology at three time points

during the pandemic and identified the factors that inhibited teachers from fully utilizing the technology available based on the meaning from teachers' responses and actions.

Contexts

This study took place at a private school for K-6 students diagnosed with dyslexia in the southeastern United States between February to October 2020. The school offered the Orton-Gillingham reading remediation for students, emphasizing multisensory methods of instruction. The total number of faculty members at the school is 55. Teachers had ample access to technology such as Smart Interactive Displays and Apple MacBook Pro laptops. Students had access to Apple iPad or Apple Macbook Airs in a one student to one device ratio.

Due to COVID-19, the school transitioned to a distance learning model in March 2020 and continued remote learning for the remainder of the school year. During this time, students and teachers took their school devices home. Teachers used Google Meet video and Seesaw for instruction. Classroom schedules were modified to contain only phonics, math, and writing instructional blocks, which were conducted synchronously. A website was created to host videos from the special teachers guiding students through physical education and music activities or listening to books read aloud. Teachers provided office hours to students to answer questions and work with students one-on-one.

The 2020-2021 school year began with hybrid instruction, and regular school hours resumed following strict health and safety guidelines. Student devices were sent home each night to ensure students were prepared to learn from home at any time if required. All classrooms were equipped with 360-degree cameras, and the school purchased a Zoom license to support a hybrid instructional model. In this model, students learning from home could join their classroom teacher's Zoom link and follow along with instruction. Seesaw and Google Classroom were again utilized to share assignments with students learning from home.

Participants

Morgan (2014) notes using quantitative methods to carefully select participants for qualitative studies allows the researcher to "target the most productive or theoretically relevant sources" (p. 17). To identify participants for this study, a survey modified from The Survey of Technology Integration and Related Factors (Pittman & Gaines, 2015) and The Technology Skills, Beliefs, and Barriers scale (Brush et al., 2008) was sent to all 55 faculty members via a Google Form. This survey collected information about how teachers use technology, how their students use technology, and what barriers they have encountered when integrating technology. Then teachers' responses were calculated and the quartile for their scores were identified. The first quartile was labeled as experienced integrators who embraced new technologies and the fourth quartile were novice integrators who lacked confidence in using technology. The two quartiles in the middle were intermediate integrators who used technology but usually waited until other teachers had success with the technology.

Purposeful sampling was used for participant selection in order to gather rich, thick descriptions from multiple individuals within this specific school context (Creswell, 2014). Specifically, a maximum variation strategy was employed to gather diverse answers and understand this phenomenon from multiple perspectives (Bloomberg & Volpe,

2016). Six teachers, two from each level of integrators, were selected (see Table 1). All six participants were female from various grade levels. Three teachers obtained a master's degree and three had a bachelor's degree. The average age was 36 years old (SD = 13.24). Teachers had varying levels of teaching experience (2-17 years). Three teachers were new to the school during the 2019-2020 school year while one teacher had been teaching at the school for 15 years. All the participants taught several different subjects. Pseudonyms were used to protect participants' privacy.

Table 1
Six Participants Selected for The Interview and Observation.

Pseudonym	Grade	Level	Subjects Taught
Stephanie	1st	Novice	Phonics, math, writing, social studies, science
Cathy	1st	Intermediate	Phonics, math, writing, social studies
Emily	3rd	Intermediate	Phonics, math, writing, social studies, science
Ollie	3rd	Novice	Phonics, math, social studies
Alice	4th	Experienced	Phonics, math, social studies
Rita	4th	Experienced	Math, writing, social studies, science

Data Collection

Data collection method included three-round semi-structured interviews and two-round classroom observations. Interviews conducted helped elicit opinions from participants to build rich, thick descriptions of barriers to implementing technology (Creswell, 2014). Observations allowed researchers to systematically and purposefully take notes of behaviors and actions within a specific context as they were occurring (Merriam & Tisdell, 2016). Furthermore, observations served to affirm or refute participants' self-reported behaviors (Mack et al., 2005). Before data collection, approval was sought from the Institutional Review Board (IRB) and the local school district to conduct research involving human subjects.

Interviews

The researchers interviewed all six participants individually three times to develop a longitudinal account of their practices of distance learning and examine how barriers changed in almost seven months. Initial interviews took place in March 2020 following the campus closing and transition to distance learning. The second interviews with participants took place in May 2020 after teachers had been instructing students remotely for approximately two months. The third round of interviews occurred in September 2020 when campus reopened and teachers were seeing students in person. Collection of each round of interview data took two weeks. Interviews were scheduled after school hours and on weekends to allow adequate time. Each interview lasted approximately 40-60 minutes. The first and second interviews were conducted through Google Meet; the third interview used Zoom. All interviews were recorded using GarageBand for transcription and analysis.

A semi-structured interview protocol was created to allow participants' unique worldviews to emerge and give the interviewer an opportunity to respond to the situation and new topics that arose (Merriam & Tisdell, 2016). It followed an open-ended format to allow participants to express their feelings and opinions freely about technology integration (Mack et al., 2005). The interview protocol was piloted with two non-participating teachers prior to data collection. One teacher felt the use of the term pedagogical beliefs was too academic for teachers, so that question was revised and elaborated with examples of teacher-centered and student-centered instruction added.

Observations

Classroom observations were conducted at two points in this study. The first observations occurred in May 2020 and utilized Google Meet to access classrooms. The second observations took place in September 2020 and occurred in person. Observations occurred in classes about different subjects such as phonics, math, and writing. A total of 12 classroom observations were conducted. Each round of observations took two weeks to complete. For classroom observations, the researchers assumed the role of observer as participant (Merriam & Tisdell, 2016). Each observation lasted the length of the class between 30 and 60 minutes. A semi-structured protocol including six sections was created based on existing observation protocols (see Table 2). Descriptive field notes about technology tools were in use and how they were being used by teachers and students were recorded to provide additional details and context for the observation.

Table 2.
Alignment of Observation Protocol and Contributing Sources

Section	Contributing Source
Setting	ISTE Classroom Observation Tool (ICOT)
Groups	ICOT Teaching Dimensions Observation Protocol (TDOP)
Teacher Activity	ICOT TDOP
Student Engagement	TDOP
Technology Activities	ICOT Looking for Technology Integration Instrument (LoFTI)
Technology Tools Used	LoFTI

Data Analysis

Inductive analysis (Creswell, 2014) was conducted to classify codes and reduce codes to themes. Codes are words or short phrases "that symbolically assign a summative, salient,

essence-capturing, and/or evocative attribute for a portion of language or visual data" (Saldaña, 2016, p. 4). Two cycles of coding were completed. The first cycle consisted of three rounds of coding with a focus on essential data, while the second cycle involved two rounds of pattern coding to elicit patterns, categories, and themes within the data (Saldaña, 2016). Throughout the data analysis process, analytic memos were recorded to document thoughts and questions.

First-cycle

All transcripts were uploaded to Delve for analysis. Codes were applied to meaningful units of text (Bogdan & Biklen, 1998). In long sentences, several codes were assigned. The first cycle of coding included three rounds.

For the first round, in vivo coding (Saldaña, 2016) was performed to analyze the interview transcripts to honor participants' voices of their experience using direct quotations such as "destroyed my whole lesson." Descriptive coding (Saldaña, 2016) was used to identify the topics that summarized teachers' actions in the observation notes in the form of nouns or short phrases, For instance, the as Drill and Practice Activity was coded for the note "She asked them to play Quizlet Live twice before they could leave class." We organized the data in Delve by participant and coded all data points (e.g., three rounds of interviews and two rounds of observations) for one participant before moving on to the next one. Using two coding methods allowed us to connect participant's interviews with observed actions at a specific point and then develop a whole story for each participant.

The second round of coding utilized process coding (Bogdan & Biklen, 1998). This method uses gerunds as codes to capture actions in the form of observable activities as well as conceptual action within the data (Miles et al., 2020). For example, the statement from Ollie "this used to be a paper-pencil activity, and with COVID I was looking for ways to move away from this" was assigned the process code Adapting Paper and Pencil Activity, which encapsulated her change in behavior to create an activity using Seesaw instead of relying on paper and pencil. During this round, some codes such as Collecting Formative Data and Providing Visuals were applied repeatedly.

Values coding was conducted for the third round to identify participants' beliefs, values, and attitudes towards technology integration. Codes labeled as values related to the importance that participants attributed to themselves, other people, things, or ideas (Miles et al., 2020), such as Accessibility and Collaboration. Statements that reflected the way participants felt about themselves, other people, things, or ideas were coded as attitudes (Miles et al., 2020) such as Enthusiastic and Critical. Saldaña (2016) identified beliefs as "part of a system that includes our values and attitudes, plus our personal knowledge, experiences, opinions, prejudices, morals, and other interpretive perceptions of the social world" (p. 132). For example, Rita's statement "I think [technology] is a really good tool to be able to engage kids and make a little bit more applicable to their lives and a little more interesting" was coded as the belief Technology Engages Students.

Second-cycle

The second cycle of coding consisted of two rounds of pattern coding (Saldaña, 2016) for the goal of identifying categories and themes. All the Delve files were exported as Microsoft Excel spreadsheets for this cycle of coding.

For the initial round of pattern coding, the researchers revisited codes generated in the first cycle and recorded patterns in a separate spreadsheet. We reviewed each participant' transcripts and codes following the sequence of time stamps for data collection. Once completing one participant's all the five transcripts, we moved to the next participant's files. After reviewing all the participants' transcripts, we reorganized the newly generated pattern codes and made edits (e.g., merging, revising, replacing) to ensure each pattern code covered all the meanings within that excerpt or sentence. Then the next step was to organize all the codes for each participant. During this process, we kept analytic memos detailing a description of their experience with technology integration in order to identify patterns for each participant. For example, when arranging the codes by participant, it was clear that Stephanie, a novice integrator, experienced more barriers than any other participant. After organizing codes by participant, we stepped away from coding for a few days to keep clear minds for the next step of categorizing. We then identified categories by comparing and contrasting pattern codes across participants. Categories were noted with relevant descriptions as they emerged. During this process, we revisited categories several times to make changes and/or decomposed some categories into more specific ones. Six categories were identified with a consensus between the researchers.

The second round of pattern coding was to elicit themes using. The researchers intentionally had a break between two rounds of pattern coding. We then revisited the categories as well as the notes in analytic memos. Several themes became apparent at this point. We then conducted a peer review session to discuss the emerging themes as each researcher explained how themes and categories were generated and answered questions from fellow researchers. Based on the feedback, we reviewed the themes together until a unanimous decision was made.

Rigor and Trustworthiness

For this study, rigor and trustworthiness of findings were ensured by four actions. First, prolonged exposure as an employee to the research site afforded the researchers a unique and thorough understanding of the context and in-depth knowledge of the phenomenon under study (Creswell, 2014). Second, member checking was performed by emailing preliminary findings to participants and requesting their checks on the accuracy (Merriam & Tisdell, 2016). All six participants responded to confirm the themes. Third, an audit trail in the forms of memos written in the margins of interview transcripts and a researcher's journal provided evidence and documentation of the decision-making process and the development of interpretations (Creswell, 2014). Finally, findings were presented in thick and rich quotes from participants.

Findings

In the end, three themes and six categories were elicited. Table 3 presents each theme along with categories, sample pattern codes, and relevant first-cycle codes.

Table 3.
Themes that Emerged from Qualitative Data

Themes	Categories	Pattern Codes	First-Cycle Codes
Distance learning influenced teachers' perceptions of technological knowledge.	Realizing the importance of technological knowledge for technology integration	Robust teacher technology knowledge Teacher technology knowledge is required	Using Specific Technology for Specific Subjects, "teacher's knowledge of technology is paramount"
	Expanding technological knowledge due to adapting to distance learning	Expanding teacher technology knowledge	Learning tools on her own, "push myself to learn something"
Distance learning ascertained teachers' attitudes about students' technological knowledge	Raising an awareness of students' technological knowledge	Student technology knowledge Teaching technology	Preparing students with technological knowledge, "Responsibility"
	Valuing students' ability to independently use technology	Independent student use of technology Technology and confidence	Students Need Technological Knowledge, "practice independent work"
Teachers experienced more first-order barriers during distance learning.	First-order barriers	Barrier: Time Barrier: Access Barrier: Other Teachers' beliefs	Barrier – Time: "handing everybody the iPad" Barrier – Access: "destroyed my whole lesson"
	Second-order barriers	Barrier: Lack of technological knowledge Barrier: Teachers' beliefs	Barrier – Technological Knowledge: "there's a lot I don't know how to do" Barrier – Teachers' Beliefs: "it was a point of frustration for her"

Theme 1: Distance Learning Influenced Teachers' Perceptions of Technological Knowledge

This theme described distance learning accentuated the need for teachers' technological knowledge, which refers to the knowledge and skills required to use technology tools (Hew & Brush, 2007). In order to effectively integrate technology, teachers and students must possess technological knowledge.

Realizing the importance of technological knowledge for technology integration

Teachers recognized that their own technological knowledge was complex and extended beyond simply knowing how to use the tools in their classrooms. All teachers realized that technological knowledge was required for effective integration, and for two teachers their lack of knowledge created a barrier to integration. For instance, Ollie, a novice integrator, acknowledged the importance of knowing how to use technology tools and the online learning environment required it even more so. She understood that technological knowledge encompassed more than knowing how to use the tools but understanding how technology could interact with their content and pedagogy.

> Ollie: The teacher's knowledge of the technology is really paramount…I feel that I do not really have enough tools in my toolbox to be effectively teaching online…once I would know more, I would also know how to instruct better.

Expanding technological knowledge due to adapting to distance learning

Four teachers credited the distance learning experience for expanding their technological knowledge. They had to quickly shift from in-person learning to synchronous online learning. Teachers identified limitations of teaching online and sought ways to overcome these limitations through technology. For Stephanie and Alice, distance learning motivated them to explore new capabilities of tools on their own and expanded their technological knowledge to meet students' needs. For Charlotte, she quickly learned that not being able to see what her students were writing presented a challenge, so she used technology to overcome this challenge. Distance learning also built teachers' confidence (e.g., Emily) in technological knowledge although teachers were thrusted into an unfamiliar challenge.

> Stephanie: I had to think of a way to do my math lesson all online. Not that I wouldn't necessarily do it the way I did, but it pushed me to have to go explore more on Braining Camp.

> Alice: I knew I needed to find something, one extra thing, and so I would say with distance learning it's made me explore more things and kind of push myself to learn something without always knowing you're an expert on it.

Theme 2: Distance Learning Ascertained Teachers' Attitudes About Students' Technological Knowledge

This theme describes that distance learning ascertained teachers' attitudes that students need technological knowledge. All six teachers spoke about student technological knowledge in their interviews.

Raising an awareness of students' technological knowledge

Distance learning experience made all the teachers aware of the importance for students to have knowledge of basic computer skills

to complete classwork and be prepared for future education. Most of them also expressed a strong sense of responsibility in teaching students that knowledge. Rita believed students needed explicit instruction in how to use technology. She took the initiative to teach her students these skills. For example, prior to transitioning to distance learning, she showed her students how to use Google Meet by having them practice presenting a book report to her from a different room in the school. Alice had strong obligations to teach students to use technology, but her motivation extended beyond that students could participate in her classroom. She recognized the need to prepare students to be digital citizens due to the prevalence of technology in our society.

> Alice: I feel, especially with older kids, obligated as a teacher to make sure that they understand just how to log onto a computer, how to write on a Google document, and how to make comments.
>
> It's definitely informed my teaching that [technology integration] needs to part of my instruction because otherwise they're going to fall behind...I want to make sure that the kids I'm teaching are prepared for life after and they're prepared for not only school but other things in their lives that require a technology.

Valuing students' ability to independently use technology

Four teachers expressed statements valuing students' independent use of technology. To Emily, students needed to know how to use the technology because it provided an opportunity for independent practice with concepts. She often structured her lessons to follow an "I do, we do, you do" format where she introduced concepts, guided students through practice work, and then gave students some type of independent practice. In order to complete their independent practice, students needed to know how to use the technology tools. As a first-grade teacher, Stephanie viewed students using technology independently as a benefit in her classroom because her students were able to show her what they could do on their own. Teachers also thought students' independent use of technology increased their confidence. Cathy noted, "technology is a way that students can feel confident in areas in the classroom."

> Emily: [Seesaw] is a good way for that independent piece where they get to do something and then I can respond to what they've done. So it provides that independent time [with technology for students].
>
> Stephanie: Some benefits in my classroom, I believe, are being able to give kids at such a young age more independence and more practice on their own because we are constantly one-on-one with them all day.

Teachers wanted students to be comfortable using technology on their own and at times made decisions regarding technology use based on this. Cathy and Alice opted to introduce fewer technology tools to ensure students were confident in their ability to independently use the tools they had introduced.

> Cathy: Because I want my students to be able to independently use the technology, I'm not using as much to overwhelm them and just slowly implement and teach them different applications once they're comfortable with other applications.

Theme 3: Teachers Experienced More First-

order Barriers During Distance Learning

All teachers in this study experienced barriers to technology integration; however, they experienced more first-order than second-order barriers.

First-order barriers

First-order barriers to technology integration are defined as those that are external to teachers but affect their teaching practices. Teachers in this study cited first-order barriers more than second-order barrier as hindering their integration.

Time. Francom (2016) found time was the most significant barrier to integration for teachers in a small school district. This barrier refers to the time it takes to learn technology as well as to implement it (Ertmer, 1999; Tang & Bao, 2021). All six teachers identified time as a barrier to integration. Time served as a barrier to integration in several ways.

Teachers stated it took time to learn new technology. For Ollie and Stephanie, learning technology took time because they needed to explore the tool, experiment with it, and imagine how it could be used in their classrooms. The time involved in learning new technology tools on her own prevented Stephanie from integrating it. Ollie also recognized that learning new technology tools required time. She found the modified schedule during distance learning gave her some time to do that, which in turn allowed her to integrate new technology.

> Stephanie: I think that's probably the biggest issue for me with technology is the planning time, like having to go out and explore it myself and make mistakes and understand it myself.
>
> Ollie: Because of distance learning, I had the time to try things out and without it, I think it would have taken me even longer to figure out how to do certain things.

Teachers mentioned the time it takes to teach students how to use technology was a barrier. Charlotte, an intermediate integrator, cited this barrier in all her interviews. During our second interview, she provided a specific example where teaching students a new technology took time. She remarked, "without me being there hands-on was difficult and it took a little while for us to understand how to be in Google Meet or if they did have a question, they'd come to back Google Meet." It was particularly challenging for her students to learn how to move between multiple apps within one class as she noted, "technology cannot just be rolled out in one [class] time because it takes time to use different productivity tools."

For experienced integrators Alice and Rita, they focused on student understanding before moving to technology, so they used class time to continue instruction if needed and eliminated the technology component.

> Rita: There had been a couple of times where if you're introducing a new skill or concept and you really just want kind of a little bit more teacher-directed [instruction] for that day for learning, and then the kids have questions and you move into some more exploratory learning where we've run out of time to incorporate more of that technology into the lesson.

Ollie and Stephanie also felt distributing devices to students or logging into accounts used valuable class time. Ollie noted, "there's a little bit of administration time left to hand everybody the iPad and then return it to its place." In addition to the time spent passing

out devices to students, Ollie lamented the time it takes to log into accounts. She stated, "This morning I got really frustrated in math. I was planning to use Braining Camp Reflector, and it took a while to sign into Braining Camp with the app."

Access. Successful technology integration requires having access to technology that is working properly when teachers and students need to use it. Wachira and Keengwe (2010) found unavailability and unreliability of technology was a major barrier to integration for teachers in their study. While the school provided plenty of technology to teachers and students, teachers identified access as a barrier to integration. Access became a barrier to integration when software was not available or not up-to-date on devices and when technology was not working properly during a lesson.

Teachers found access to be a barrier when software was not available or up to date. Stephanie took her students to view a fifth-grade exhibit created by students about the Lascaux Caves in France. Students needed to use the camera app on their iPads to scan QR codes, and "we brought all of our iPads there, but we didn't have a camera app [on our iPads]." Teachers also encountered instances where technology such as smartboard was not working properly.

> Alice: There was one day where the Smartboard just decided to not even turn on…We got through it, but it really kind of destroyed my whole lesson because a lot of it you have to be able to see what I'm talking about.

> Rita: In the beginning of the year when our Smartboard was kind of funky and sometimes working, sometimes not, that was a little bit tricky and a little bit of a barrier because we couldn't share [anything] through the board with everybody.

Co-teacher's beliefs. Ertmer et al. (2012) found other teachers' beliefs to be the biggest obstacle to integration for teachers in their study. The school dynamic of having two teachers in every classroom influenced participants' technology integration. For two teachers, their co-teachers' beliefs served as a barrier to their integration.

Alice's co-teacher's beliefs did create a barrier to her integration. She stated during distance learning, "[My co-teacher] wasn't negative because she's happy all the time, but [technology] was a point of frustration for her at times, so we just wouldn't use it." Her co-teacher's frustration with technology prevented her from using some tools that she would have otherwise used. This continued after we returned to in-person learning in the fall. When asked in her third interview about other teacher's beliefs being a barrier, she stated, Alice mentioned their differing views about technology ultimately led her to abandon technology use in some lessons.

> Alice: It is the same answer as last time. I think it's a stress inducing and frustrating situation at times. If [other teachers] are not willing to hear suggestions or incorporate your ideas, it can be really difficult to continue on with the lesson with that. I have tended to let it go and say "Okay, we won't do that. We'll just do something else."

Second-order barriers

Second-order barriers are defined as those that are internal to teachers (Ertmer, 1999). Two novice integrators and one intermediate integrator experienced second-order barriers. Their lack of technological knowledge and their own beliefs prevented them from

successfully integrating technology.

Technological knowledge. Technological knowledge served as a barrier to integration because they did not know how to use them. For example, Ollie admitted on several occasions that her knowledge and skills relating to technology were not robust. She stated during her first interview, "The obstacle is really my knowledge, not so much the students' knowledge." Distance learning required her to learn new technology tools to instruct her students and share learning activities with them. While she learned tools such as Google Meet and Seesaw, she continued to acknowledge a deficit in her technological knowledge. During our second interview, she said "I really do have a handicap there. There is still a lot that I am unsure about and do not know how to do, and it's, of course, frustrating not having that [knowledge]." Her frustration with technology was witnessed during the second observation. She was using Reflector to display her iPad screen on the Smartboard, and Reflector quit when her iPad went to sleep while she was helping a student. Even after the distance learning experience and seeing an increase in her technology use, she continued to identify her technological knowledge as a barrier stating, "The greatest hindrance really is my own knowledge."

Teacher's beliefs. Teacher's beliefs are defined as the beliefs teacher's hold about teaching and learning and their confidence in their abilities to use technology. Both novice integrators made statements revealing their beliefs served as a barrier to integration.

Novice integrators held strong beliefs about incorporating multisensory elements into their lessons. Stephanie expressed the belief that writing with a pencil was a superior multisensory method preferable to any other instructional methods. For her, technology did not provide the same benefits to students with dyslexia as multisensory methods. This belief persisted throughout the distance learning period as she mentioned in her third interview that student could not learn as well online as in person.

> Stephanie: (2nd interview) My understanding is that writing physically is the best. So chalk or a pencil, I think we rely heavily on pencil, but that helps that connection in the brain. I don't think [technology will] ever replace one-on-one instruction because, especially with our model of the hands-on learning, that is what our population needs.

Ollie and Stephanie also lacked confidence in their technology use, which led them to avoid using technology. Ollie viewed using technology as taking a risk because she was unsure of how to handle problems if they arose. Stephanie expressed that part of her discomfort related to a feeling of failure. She was discouraged by unsuccessful attempts, and these experiences decreased her confidence in integrating technology.

> Ollie: With technology, I often feel like [I'm] taking a risk...I really don't like that risk taking. I always like to have a plan B.

> Stephanie: You feel like you got this and then if you add this other level, [teachers] feel like a failure at teaching if they can't implement it, or I do when I can't implement it.

Discussion

The longitudinal nature of this study revealed teachers' perceptions of enablers and barriers over time through the distance learning experience. This study found teachers' technological knowledge to technology integration has evolved during

distance learning. Additionally, teachers have developed positive attitude about the importance of teaching students to use technology effectively. Furthermore, teachers faced both kinds of barriers, but they experienced more first-order barriers than second-order barriers. The findings of this study add to the existing literature on technology integration and teacher education.

Distance learning affected teachers' perception of those enablers to technology integration such as technological knowledge, beliefs, and also their attitude towards students' technological knowledge and skills. Due to COVID-19, the school instituted a policy requiring teachers to instruct students in a virtual environment. Teachers were thrust into distance learning with little time to train or prepare for their new online classrooms. This experience impacted teachers' beliefs about technology, which supported Tondeur et al.'s (2018) findings that school context played a part in shaping teachers' beliefs. Furthermore, in a longitudinal perspective, five teachers in this study expressed changes in their attitude and beliefs about technology after the experience of distance learning, which supported previous research findings that teachers' beliefs changed after participating in a technology-rich environment (Levin & Wadmany, 2008), such as distance learning (Kwon et al., 2019). Being immersed in the technology-rich environment provided by distance learning helped teachers expand their technological knowledge about integrating technology. Teachers also realized their responsibility to teach students how to use technology that prepared students for future education.

All teachers in this study experienced first-order barriers, which supported previous findings that external barriers hindered technology integration (An & Reigeluth, 2011; Francom, 2016; Wachira & Keengwe, 2010). All six participants identified time as a barrier during interviews and elaborated on the ways it hindered their technology integration (An & Reigeluth, 2011; Francom, 2016; Hew & Brush, 2007; Hsu, 2016). In addition, teachers encountered access as a barrier when technology was not updated or not working properly, echoing prior findings (Francom, 2016; Wachira & Keengwe, 2010). The most frequently cited unreliable technology was Smartboards that did not work. These findings suggested that increasing the number of devices available to teachers did not eliminate access being a barrier. Rather, devices must be maintained in order to ensure teachers have access to hardware and software that are reliable and functioning properly. Furthermore, teachers in this study found their technology integration was hindered by their co-teachers that supported previous findings (Ertmer et al., 2012). The school context of having two teachers in a classroom lended itself to situations such as these. Historically, the two classroom teachers held different positions where one teacher was considered the lead teacher and the other one was the associate teacher. This dynamic created a hierarchical classroom structure where the lead teacher's beliefs and practices dominated the classroom. Brouck (2007) described tensions created by the co-teacher dynamic such as decreased teacher autonomy and constrained teacher roles as well as feelings of being devalued. The co-teacher dynamic in Alice's and Stephanie's classrooms demonstrated this tension. Because their co-teachers did not share their beliefs about the role of technology, they experienced decreased their teacher autonomy when attempting to integrate technology.

Second-order barriers describe those internal to teachers such as their beliefs about the role of technology in teaching and

learning, their willingness to change, and their technological knowledge. Two teachers in this study viewed technology as a supplement to integration. As such, they did not see the need to use technology to aid student learning. Furthermore, they believed multisensory methods were preferable to technology use. These beliefs affected their use of technology in their classrooms, supporting the previous research (Gu et al., 2013; Hermans et al., 2008; Hew & Brush, 2007; Jones et al., 2017). In addition, lack of technological knowledge was a significant barrier for novice integrators, supporting previous findings (Hew & Brush, 2007; Hsu, 2016; Jones et al., 2017). Teachers are not likely to use technology in their classrooms if they lack the knowledge to use it. Two teachers in this study thus preferred tools that were familiar to them, and this resulted in limited technology use. Teachers' beliefs and technological knowledge can affect one another (Hew & Brush, 2007). Previous studies found teachers' lack of technological knowledge affected their confidence in using tools (Gu et al., 2013; Holden & Rada, 2011; Vareberg & Platt, 2018). This was evident with the two novice integrators in this study. For Ollie and Stephanie, the fear of technology failing and not having the technological knowledge to troubleshoot decreased their use.

The relationship between first-order and second-order barriers is complex. Ertmer (1999) outlined that differences in how teachers perceive first-order barriers can determine higher levels of technology use. Furthermore, teachers' pedagogical beliefs and classroom practices can affect how they perceive first-order barriers and the relative weight they assign to these barriers (Ertmer, 1999). Findings from this study seem to show evidence of this. For example, experienced integrators demonstrated strong technological knowledge; however, one barrier they faced was time. Both experienced integrators stated in interviews they occasionally ran out of time to implement technology into their lessons. This instance of time as a barrier did not align with the reasons time served as a barrier for the other teachers in this study. Additionally, experienced integrators stated they were able to incorporate the technology in later lessons. Their strong technological knowledge allowed them to easily make changes to when and where they integrated technology into their lessons. Thus, time served as an immediate barrier to integration during lessons, but it did not carry much weight as they were ultimately able to integrate technology at a later time. Research into strategies to overcome barriers has highlighted how teachers' beliefs and practices can reduce barriers they face (Ertmer et al., 2012; Walker & Shepard, 2011). Both experienced integrators demonstrated strong technological knowledge during their observations. Their strong technological knowledge reduced barriers they might have faced such as access and technical support.

Practical Implications

Action steps to reduce first-order barriers are recommended. First, researching ways to minimize time to log in and distribute devices is needed. Single sign-on software may streamline the login process and save class time. Reducing the time spent distributing technology could be accomplished by organizing the classroom differently or assigning a student or the co-teacher to pass out technology in the morning. Second, given the school's arrangement of two teachers in every classroom, careful consideration of teaching teams is recommended. While many factors are weighed when choosing to pair two teachers, teachers' beliefs about the role of technology for teaching and learning should be included as well. Third, additional training on the different co-teaching models could also benefit teaching teams by introducing or

reviewing teaching models that demonstrate an equal working relationship (Cook & Friend, 1995). Fourth, to increase teacher access to technology, several systems could be implemented such as offering technology training on installing and updating software and periodical device review for teachers (Michael, 1998).

Limitations and Future Research

This current study is subject to limitations. First, although the researchers followed rigorous procedures to ensure the rigor and trustworthiness of qualitative findings, our subjectivities can present biases in how findings are interpreted (Roulston & Shelton, 2015). Second, our data collection was impacted by some restrictions in order to meet the COVID-19 safety protocol. Our initial observations were conducted online, and it limited our capacity of observing the whole classroom. Future research could examine technology integration with an emphasis on identifying pedagogical strategies for online learning that work well with the Orton-Gillingham Approach at schools for students with dyslexia. In addition, future research may look into teachers' specific barriers in a longitudinal perspective so as to reduce or eliminate those barriers.

Declaration of Interest Statement

There is not any potential conflict of interest in the work.

Data Availability Statement

The datasets generated during and/or analyzed during the current study are not publicly available due to the requirement of Institutional Review Board approval but are available from the corresponding author on reasonable request.

Author Information

Holli Bice
University of South Carolina, U.S.A.
hbice@email.sc.edu

Hengtao Tang
University of South Carolina, U.S.A.
htang@mailbox.sc.edu

References

An, Y., & Reigeluth, C. (2011). Creating technology-enhanced, learner-centered classrooms: K–12 teachers' beliefs, perceptions, barriers, and support needs. *Journal of Digital Learning in Teacher Education, 28*(2), 54–62. https://doi.org/10.1080/21532974.2011.10784681

Archambault, L., & Larson, J. (2015). Pioneering the digital age of instruction: Learning from and about K-12 online teachers. *Journal of Online Learning Research, 1*(1), 49–83.

Bice, H., & Tang, H. (2022). Teachers' beliefs and practices of technology integration at a school for students with dyslexia: A mixed methods study. *Education and Information Technologies, 27*(7), 10179-10205. https://doi.org/10.1007/s10639-022-11044-1

Blackwell, C. K., Lauricella, A. R., Wartella, E., Robb, M., & Schomburg, R. (2013). Adoption and use of technology in early education: The interplay of extrinsic barriers and teacher attitudes. *Computers and Education, 69*, 310–319. https://doi.org/10.1016/j.compedu.2013.07.024

Bloomberg, L. D., & Volpe, M. (2016). *Completing your qualitative dissertation: A road map from beginning to end*. Thousand Oaks, CA: Sage.

Bouck, E. C., (2007). Co-teaching…not just a textbook term: Implications for practice. *Preventing School Failure, 51*(2), 46-51.

Bogdan, R. C., & Biklen, S. K. (1998). *Qualitative research for education: An introduction to theory and methods* (3rd ed.).

Brush, T., Glazewski, K. D., & Hew, K. F. (2008). Development of an instrument to measure preservice teachers' technology skills, technology beliefs, and technology barriers. *Computers in the Schools, 25*(1–2), 112–125. https://doi.org/10.1080/07380560802157972

Choudhury, S., & Pattnaik, S. (2020). Emerging themes in e-learning: A review from the stakeholders' perspective. *Computers & Education, 144*, 103657.

Coleman, L. O., Gibson, P., Cotten, S. R., Howell-Moroney, M., & Stringer, K. (2016). Integrating computing across the curriculum. *Journal of Educational Computing Research, 54*(2), 275–294. https://doi.org/10.1177/0735633115616645

Cook, L., & Friend, M. (1995). Co-teaching: Guidelines for creating effective practices. *Focus on Exceptional Children, 28*(3), 1-16.

Creswell, J. W. (2014). *Research design: Qualitative, quantitative, and mixed method approaches* (4th ed.). Sage.

Ertmer, P. A. (1999). Addressing first- and second-order barriers to change: Strategies for technology integration. *Educational Technology Research and Development, 47*, 47–61. https://doi.org/10.1007/BF02299597

Ertmer, P. A., Ottenbreit-Leftwich, A. T., Sadik, O., Sendurur, E., & Sendurur, P. (2012). Teacher beliefs and technology integration practices: A critical relationship. *Computers and Education, 59*(2), 423-435. https://doi.org/10.1016/j.compedu.2012.02.001

Ertmer, P. A., Ottenbreit-Leftwich, A., & York, C. S. (2006). Exemplary technology-using teachers. *Journal of Computing in Teacher Education, 23*(2), 55-61. https://doi.org/10.1080/10402454.2006.10784561

Francom, G. M. (2016). Barriers to technology use in large and small school districts. *Journal of Information Technology Education: Research, 15*, 577–591. Retrieved from http://www.informingscience.org/Publications/3596

Greer, D., Rowland, A. L., & Smith, S. J. (2019). Critical considerations for teaching students with disabilities

in online environments. *Teaching Exceptional Children*. https://doi.org/10.1177/0040059914528105

Gu, X., Zhu, Y., & Guo, X. (2013). Meeting the "digital natives": Understanding the acceptance of technology in classrooms. *Educational Technology & Society, 16*(1), 392–402.

Heath, M. K. (2017). Teacher-initiated one-to-one technology initiatives: How teacher self-efficacy and beliefs help overcome barrier thresholds to implementation. *Computers in the Schools, 34*(1–2), 88–106. https://doi.org/10.1080/07380569.2017.1305879

Hew, K. F., & Brush, T. (2007). Integrating technology into K-12 teaching and learning: Current knowledge gaps and recommendations for future research. *Educational Technology Research and Development, 55*(3), 223–252. https://doi.org/10.1007/s11423-006-9022-5

Holden, H., & Rada, R. (2011). Understanding the influence of perceived usability and technology self-efficacy on teachers' technology acceptance. *Journal of Research on Technology in Education, 43*(4), 343–367. https://doi.org/10.1080/15391523.2011.10782576

Hsu, P. S. (2016). Examining current beliefs, practices and barriers about technology integration: A case study. *TechTrends, 60*(1), 30–40. https://doi.org/10.1007/s11528-015-0014-3

Jones, W. M., Smith, S., & Cohen, J. (2017). Preservice teachers' beliefs about using maker activities in formal K-12 educational settings: A multi-institutional study. *Journal of Research on Technology in Education, 49*(3–4), 134–148. https://doi.org/10.1080/15391523.2017.1318097A

Kayaduman, H., & Demirel, T. (2019). Investigating the concerns of first-time distance education instructors. *International Review of Research in Open and Distributed Learning, 20*(5), 85-103.

Kopcha, T. J. (2012). Teachers' perceptions of the barriers to technology integration and practices with technology under situated professional development. *Computers and Education, 59*(4), 1109–1121. https://doi.org/10.1016/j.compedu.2012.05.014

Kwon, K., Park, S. J., Shin, S., & Chang, C. Y. (2019). Effects of different types of instructor comments in online discussions. *Distance Education, 40*(2), 226-242.

Levin, T., & Wadmany, R. (2008). Teachers' views on factors affecting effective integration of information technology in the classroom: Developmental scenery. *Journal of Technology and Teacher Education, 16*, 233–263.

Li, K., Li, Y., & Franklin, T. (2016). Preservice teachers' intention to adopt technology in their future classrooms. *Journal of Educational Computing Research, 54*(7), 946–966. https://doi.org/10.1177/0735633116641694

Mack, N., Woodsong, C., Macqueen, K. M., Guest, G., & Namey, E. (2005). *Qualitative research methods: A data collector's field guide.* Family Health International.

Makki, T. W., O'Neal, L. T. J., Cotten, S. R., & Rikard, R. V. (2018). When first-order barriers are high: A comparison of second- and third-order barriers to classroom computing integration. *Computers and Education, 120,* 90–97. https://doi.org/10.1016/j.compedu.2018.01.005

McCulloch, A. W., Hollebrands, K., Lee, H., Harrison, T., & Mutlu, A. (2018). Factors that influence secondary mathematics teachers' integration of technology in mathematics lessons. *Computers and Education, 123,* 26–40. https://doi.org/10.1016/j.compedu.2018.04.008

Merriam, S. B., & Tisdell, E. J. (2016). *Qualitative research: A guide to design*

and Implementation (4th ed.). Jossey-Bass Publications.

Miles, M. B., Huberman, A. M. & Saldaña, J. (2020). *Qualitative data analysis: A methods sourcebook* (4th ed.). Sage.

Miranda, H. P., & Russell, M. (2012). Understanding factors associated with teacher-directed student use of technology in elementary classrooms: A structural equation modeling approach. *British Journal of Educational Technology, 43,* 652–666. https://doi.org/10.1111/j.1467-8535.2011.01228.x

Morgan, D. (2014). *Integrating qualitative and quantitative methods: A pragmatic approach*. Sage.

Mueller, J., Wood, E., Willoughby, T., Ross, C., & Specht, J. (2008). Identifying discriminating variables between teachers who fully integrate computers and teachers with limited integration. *Computers and Education, 51*(4), 1523–1537. https://doi.org/10.1016/j.compedu.2008.02.003

Petko, D. (2012). Teachers' pedagogical beliefs and their use of digital media in classrooms: Sharpening the focus of the "will, skill, tool" model and integrating teachers' constructivist orientations. *Computers and Education, 58*(4), 1351–1359. https://doi.org/10.1016/j.compedu.2011.12.013

Pittman, T., & Gaines, T. (2015). Technology integration in third, fourth and fifth grade classrooms in a Florida school district. *Educational Technology Research and Development, 63*(4), 539–554. https://doi.org/10.1007/s11423-015-9391-8

Read, K., Tang, H., Lovett, A., & Bodily, R. (2020). Understanding the impact of OER courses in relation to student socioeconomic status and employment. *International Journal of Open Educational Resources, 3*(1). https://doi.org/10.18278/ijoer.3.1.5

Roulston, K., & Shelton, S. A. (2015). Reconceptualizing bias in teaching qualitative research methods. *Qualitative Inquiry, 21*(4), 332–342. https://doi.org/10.1177/1077800414563803

Saldaña, J. (2016). *The coding manual for qualitative researchers* (2nd ed.). Sage Publications Ltd.

Schroth, S., Tang, H., AlQahtani, M., & Carr-Chellman, A. (2019). The use of OSMO tangram and traditional tangram manipulatives in a math course of an elementary school: An exploratory study. *Journal of Educational Technology Development and Exchange, 11*(1), Article 1. https://doi.org/10.18785/jetde.1101.01

Shifflet, R., & Weilbacher, G. (2015). Teacher beliefs and their influence on technology use: A case study. *Contemporary Issues in Technology & Teacher Education, 15*(3), 1–50. https://doi.org/10.1109/IEMBS.2010.5627465

Tang, H. & Bao. Y. (2021). A person-centered approach to understanding K-12 teachers' barriers in implementing open educational resources. *Distance Education, 42*(4), 582-598. https://doi.org/10.1080/01587919.2021.1986371

Tang, H., Wang, S., Qian, Y., & Peck, K. (2016). Students' perceptions of online instructors' roles in a Massive Open Online Course, In S. D'Agustino (Ed.), *Creating Teacher Immediacy in Online Learning Environments*, pp. 273-289, IGI Global.

Tondeur, J., Aesaert, K., Prestridge, S., & Consuegra, E. (2018). A multilevel analysis of what matters in the training of pre-service teacher's ICT competencies. *Computers & Education, 122*, 32–42. https://doi.org/10.1016/j.compedu.2018.03.002

U.S. Department of Education. (2017). *Reimagining the role of technology in education: 2017 National Technology Plan update.* Washington, DC: U.S.

Department of Education.

van Braak, J., Tondeur, J., & Valcke, M. (2004). Explaining different types of computer use among primary school teachers. European *Journal of Psychology of Education, 19*(4), 407–422. https://doi.org/10.1007/BF03173218

Vannatta, R. A., & Fordham, N. (2004). Teacher dispositions as predictors of classroom technology use. *Journal of Research on Technology in Education, 36*(3), 253–271.

Vareberg, K., & Platt, C. A. (2018). Little tech on the prairie: Understanding teachers' adoption of and resistance to technology in the rural classroom. *Journal of the Communication, Speech & Theatre Association of North Dakota, 31*, 27–42.

Wachira, P., & Keengwe, J. (2010). Technology integration barriers: Urban school mathematics teachers' perspectives. *Journal of Science Education and Technology, 20*(1), 17–25. https://doi.org/10.1007/s10956-010-9230-y

Yang, B., Tang, H., Hao, L., & Rose, J. (2022), Untangling chaos in discussion forums: A temporal analysis of topic-relevant forum posts in MOOCs, *Computers & Education, 178*(2022), 104402. https://doi.org/10.1016/j.compedu.2021.104402

Yin, R. K. (2012). Case study methods. In H. Cooper, P. M. Camic, D. L. Long, A. T. Panter, D. Rindskopf, & K. J. Sher (Eds.), *APA handbook of research methods in psychology, Vol. 2. Research designs: Quantitative, qualitative, neuropsychological, and biological* (pp. 141–155). American Psychological Association. https://doi.org/10.1037/13620-009