INVESTIGATING THE RELATIONSHIP BETWEEN K-12 ONLINE SPECIAL EDUCATION TEACHERS' TPACK AND TEACHER LEVEL VARIABLES: A CONVERGENT DESIGN MIXED-METHODS STUDY

by

Brad R. Garrison

A dissertation

submitted in partial fulfillment

of the requirements for the degree of

Doctor of Education in Educational Technology

Boise State University

August 2023

BOISE STATE UNIVERSITY GRADUATE COLLEGE

DEFENSE COMMITTEE AND FINAL READING APPROVALS

of the dissertation submitted by

Brad R. Garrison

Dissertation Title: Investigating the Relationship Between K-12 Online Special Education Teacher TPACK and Teacher Level Variables: A Convergent Mixed-Methods Study

Date of Final Oral Examination: 03 April 2023

The following individuals read and discussed the dissertation submitted by student Brad R. Garrison, and they evaluated the student's presentation and response to questions during the final oral examination. They found that the student passed the final oral examination.

Jui-Long Hung, Ed.D.	Chair, Supervisory Committee
Kerry Rice, Ed.D.	Member, Supervisory Committee
Chareen Snelson, Ed.D.	Member, Supervisory Committee

The final reading approval of the dissertation was granted by Jui-Long Hung, Ed.D., Chair of the Supervisory Committee. The dissertation was approved by the Graduate College.

DEDICATION

I would like to dedicate this dissertation to my loving family who have supported me during every step of this journey.

ACKNOWLEDGMENTS

I am so thankful to the many wonderful Boise State faculty members who have aided the development of my academic abilities and supported me across the finish line. I would like to especially thank my advisor, Dr. Hung, my committee members, Dr. Rice and Dr. Snelson.

ABSTRACT

K-12 students with disabilities in the United States are increasingly enrolling in online schools and educational programs. Therefore, K-12 online public and charter school special education (SpecEd) teachers must be prepared to develop and implement individualized educational plans (IEPs) that meet the procedural and substantive requirements of federal and state SpecEd law. Currently, the research literature is lacking in descriptions of instructional techniques and interventions that K-12 online special education teachers (SETs) are implementing in their practice. To address this need, this convergent design mixed-methods study made use of the Technological, Pedagogical, and Content knowledge (TPACK) framework in order to (1) measure the self-assessed TPACK of a sample of K-12 online SETs working at online secondary schools in the United States using a validated survey instrument, (2) investigate the relationship between teacher level predictor variables (age, online teaching experience, education level, and certification status) and the criterion variable of teachers' TPACK using hierarchical multiple regression techniques, (3) analyze participants qualitative responses to a researcher created questionnaire to locate evidence of participants' applied TPACK in their self-reported online teaching practices, and (4) look for evidence of convergence and/or divergence between the quantitative and qualitative findings. Standard multiple regression analyses led to the identification of five significant regression models, with criterion variables of (1) mean TPCK, (2) mean TPK, (3) mean TCK, (4) mean PCK, and (5) mean TK. Qualitative data analysis yielded evidence that participants applied TPACK significantly impacted their practice, including through the implementation of 21 out of 22 High Leverage Practices (HLPs). The qualitative data suggested that TPK and PK were factors that most informed participants' reported online teaching practices. However, little evidence was found for participants' use of explicit instructional techniques, and several other important HLPs. Additionally, no qualitative evidence was found indicating participants' use of FBAs and/or development of behavior support plans for students. Mixed methods analysis yielded two convergent findings related to (1) a possible negative relationship between participant age and TK, and (2) strong estimations of participant PK. Two divergent findings related to asymmetries observed between (1) participants' relatively low self-reported TPK, and the large amount of qualitative evidence suggesting the application of participant TPK in their online teaching practice, and (2) participants' relatively high self-reported CK, and the lack of qualitative evidence indicating the direct application of participant CK in practice.

TABLE OF CONTENTS

DEDICATION ……………………………………………………………..………..…iv

ACKNOWLEDGMENTS…………………………………………………………………v

ABSTRACT………………………………………………………………………………vi

LIST OF TABLES………………………………………………………………….xvi

LIST OF FIGURES………………………………………………………………...xvii

LIST OF ABBREVIATIONS…………………………………………………..xviii

CHAPTER ONE: INTRODUCTION……………………………………………………1

Problem Statement……………………………………………………………..1

Theoretical Framework……….…………………………………………………..2

TPACK………………………………………………………………....2

High Leverage Practices for SpecEd……………………………………...3

Purpose Statement……………………………………………………………...5

Research Approach……………………………………………………………..6

Research Questions……………………………………………………..6

Sample…………………………………………………………………..6

Data Collection and Analysis……………………………………………...7

Significance of the Study……………………………………………………………….8

Assumptions………………………………………………………………………….8

Summary……………………………………………………………………………9

CHAPTER TWO: LITERATURE REVIEW…………………………………………11

K-12 OLT&L……………………………………………………………………….12

Online vs. Traditional Schools…………………………………………...15

Potential Benefits of Online Schooling for SWDs………………………19

Challenges Related to K-12 Online Schooling…………………………..21

Legal and/or Ethical Challenges…………………………………26

The Role and Impact of Parents/Caregivers in K-12 Online Schooling…28

The Role of K-12 Online Teachers and "Best Practices" in Online School…………………………………………………………………………....3`

Teacher Knowledge, Skills and Characteristics………………….35

K-12 Online Learning Curriculum……………………………………….36

"Interaction" in K-12 Online Schools……………………………………37

"Engagement" in K-12 Online Schools…………………………………..39

Universal Design for Learning, Assistive Technology, and Accessibility……………………………………………………………………..……41

Professional Development and Teacher Preparation for K-12 OLT&L…………………………………………………………………………..………42

K-12 OLT&L Theoretical Frameworks…………………………………44

TPACK……………………………………………………………………..45

TPACK Measurement……………………………………………………48

The SPTKTT (Schmidt et al., 2009)……………………………..49

Qualitative Evaluations and Descriptions of TPACK…………...58

Correlations between TPACK and Other Teacher Level Variables…….67

TPACK and Gender……………………………………………...67

TPACK and Teacher Age………………………………………..69

TPACK and Teaching Experience…………………………….....70

TPACK and Self-Efficacy………………………………………73

TPACK and Student Outcomes…………………………………………74

TPACK Research in SpecEd……………………………………………77

Identified Research Gaps and Future Research Needs…………………………..85

Summary of Findings from Similar Studies……………………………………..86

CHAPTER THREE: METHODOLOGY………………………………………………..88

Purpose Statement…………………………………………………………………88

Research Design……………………………………………………..……..88

Research Context…………………………………………………………..…90

Researcher Subjectivity……………………………………………….…...90

Ethics…………………………………………………………………….…...91

Participants…………………………………………………………..……..92

Data Collection and Analysis……………………………………………..93

Instruments………………………………………………………………..96

Demographics Survey……………………………………………..97

TPACK Survey……………………………………………………97

Qualitative Questionnaire…………………………………………98

Summary…………………………………………………………………..99

CHAPTER FOUR: RESULTS………………………………………………………100

Purpose Statement…………………………………………………………100

Overview…………………………………………………………………..100

Sample Demographics……………………………………………………101

Quantitative Results ……………………………………………………....103

TPACK.xs Response Statistics………………………………………....104

Multiple Regression Analyses…………………………………………106

Checking the Assumptions of Multiple Regression…………………....116

Qualitative Results……….………………………………………………117

Qualitative Evidence of Participants' Applied TK…………………….122

TK and HLPs……………………………………………………..123

Qualitative Evidence of Participants' Applied PK…………………….124

PK and HLPs……………………...………………………125

Qualitative Evidence of Participants' Applied CK…………………..…129

Qualitative Evidence of Participants' Applied TPK……………………129

TPK and HLPs…………………………………………………133

Qualitative Evidence of Participants' Applied TCK………………..…137

TCK and HLPs…………………………………………….....138

Qualitative Evidence of Participants' Applied PCK……………………138

PCK and HLPs…………………………………………….....139

Qualitative Evidence of Participants' Applied TPCK……………...…140

TPCK and HLPs…………………………………………….....141

Challenges Identified by Participants……………………………....143

Mixed-Methods Results………………………………………….........145

Convergent Results…………………………………………………145

Divergent Results……………………………………………………146

Summary……………………………………………………………………148

CHAPTER FIVE: DISCUSSION……………………………………………...151

Purpose Statement…………………………………………………………151

Discussion of Research Findings……………………………………………151

Quantitative Findings and Discussion…………………….…………151

Significant Regression Model with Criterion Variable of Mean TPCK…………………………………………………………...152

Significant Regression Model with Criterion Variable of Mean TPK…………………………………………………………..154

Significant Regression Model with Criterion Variable of Mean TCK…………………………………………………………..154

Significant Regression Model with Criterion Variable of Mean PCK……………………………………………………………..155

Significant Regression Model with Criterion Variable of Mean TK…………………………………………………………........155

Discussion of Non-Significant Findings……………………….156

Qualitative Findings and Discussion…………………………………...157

Applied TPACK and HLP Implementation…………………….159

Mixed-Methods Findings and Discussion……………………………...164

Convergent Findings…………………………………………….165

Divergent Findings……………………………………………...166

Implications………………………………………………………………..168

Recommendations for Future Research………………………………...171

Limitations………………………………………………………………...173

Significant Contributions of the Study…………………………………174

Conclusion………………………………………………………………...174

REFERENCES………………………………………………………………………179

APPENDIX A……………………………………………………………………….216

The High Leverage Practices for Special Education…………………………...217

APPENDIX B…………………………………………………………………..……219

Demographic Survey……………………………………………………...220

APPENDIX C…………………………………………………………………..……224

TPACK.xs Survey………………………………………………………...225

APPENDIX D…………………………………………………………………..……228

Qualitative Questionnaire…………………………………………………229

LIST OF TABLES

Table 1 Research Questions, Data Collection Instruments, and Data Analysis Methods......89

Table 2 States in Which Participants Are Employed……...101

Table 3 Mean TPACK.xs Scores for Participant Sample…....104

Table 4 Multiple Regression Results….112

Table 5 ANOVA Statistics for All Regression Models…113

Table 6 Significant Regression Models… 115

Table 7 Number of Items in Participants' Qualitative Responses Coded for Each TPACK Factor….120

Table 8 Number of Items in Participants' Qualitative Responses Coded for Each HLP…..120

Table 9 Mixed-Methods Findings….148

LIST OF FIGURES

Figure 1 Conceptual Framework……………………………………………………..9

Figure 2 TPACK Visual Representation………………………………………….47

Figure 3 A Visual Representation of Descriptive and Pattern Codes……………119

LIST OF ABBREVIATIONS

TPACK	Technological, Pedagogical and Content Knowledge
TK	Technological Knowledge
PK	Pedagogical Knowledge
CK	Content Knowledge
TPK	Technological Pedagogical Knowledge
TCK	Technological Content Knowledge
PCK	Pedagogical Content Knowledge
TPCK	Technological Pedagogical Content Knowledge
SET	Special Education Teacher
OLT&L	Online Teaching and Learning
IDEA	Individuals with Disabilities in Education Act
SpecEd	Special Education
SWDs	Students with Disabilities
IEP	Individualized Educational Plan
FBA	Functional Behavioral Assessment

BIP	Behavior Intervention Plan
EBP	Evidenced-Based Practice
PST	Pre-Service Teacher
IST	In-Service Teacher
UDL	Universal Design for Learning
RQ	Research Question
HLPs	High Leverage Practices

CHAPTER ONE: INTRODUCTION

An increasing number of K-12 students in the United States are enrolling in online or "virtual" public and charter schools, including students with disabilities (SWDs; Allday & Allday, 2011). Students who, after being evaluated by a school psychologist, are found to have one or more disabilities negatively impacting their ability to access the general education curriculum qualify for SpecEd services and supports under the Individuals with Disabilities in Education Improvement Act (IDEA, 2004). IDEA mandates that an individualized education plan (IEP) is developed and implemented for SWDs qualifying for SpecEd services. Currently, large numbers of students with IEPs are enrolled in online schools (Allday & Allday, 2011). These students are reliant upon services overseen and/or provided by online special education teachers (SETs). It is therefore imperative that online schools and online SETs are prepared to provide legally compliant SpecEd services and supports, and to ensure that SWDs are able to benefit meaningfully from the educational opportunities provided to them in online schools.

Problem Statement

Students with disabilities receiving SpecEd services are increasingly enrolling in K-12 online public and charter schools (Allday & Allday, 2011). As such, online schools are being tasked with providing procedurally and substantively compliant SpecEd services. Online SETs are largely responsible for overseeing and/or providing such services. Researchers have suggested that online teaching requires a different skill set from traditional brick-and-mortar teaching (Corry & Stella, 2012; Tonks et al., 2021). For example, compared to traditional classroom instruction, online teaching may require greater text-based communication skills (Borup & Stevens, 2017), instructional design skills (Pulham & Graham, 2018), knowledge of online discussion facilitation (Pulham & Graham, 2018), and technological skills (DiPietro et al., 2008). However, to date, relatively little academic research has explored the knowledge, skills and instructional practices associated with effective online SpecEd service delivery.

Theoretical Framework

The current study is guided by a theoretical framework that brings together the Technological, Pedagogical and Content Knowledge (TPACK) framework (Koehler & Mishra, 2005), and the High-Leverage Practices (HLPs) for special education. Together, these frameworks are used to characterize the knowledge and skills (applied knowledge) that online SETs utilize in their teaching practice. Ultimately, the construct of effective online SET practice can be at least partially defined in terms of (relatively high) levels of SET TPACK, and SETs' frequent and consistent implementation of HLPs with fidelity.

TPACK

The integration of digital technologies into instruction is a central component of K-12 education in the 21st century (Jansen & Van Der Merwe, 2015), and this is perhaps especially true in online instructional contexts, where the daily use of digital tools is fundamental to the learning modality. The TPACK framework (Koehler & Mishra, 2005) has been used in K-12 education to characterize the types of knowledge and skills that teachers require to effectively integrate technology into their instruction. More generally, the TPACK framework can be used to characterize effective teaching practice in the 21st century, which is often inseparable from the use of digital educational technologies. For this reason, TPACK can be used as a theoretical framework for research exploring online K-12 teaching practices in both general and SpecEd contexts (Ames et al, 2021; DiPietro et al., 2008; Ward & Kushner-Benson, 2010).

The TPACK framework consists of seven individual factors representing the types of knowledge that are involved in teachers' use of technology for learning: (1) Technological knowledge (TK), (2) Pedagogical knowledge (PK), (3) Content Knowledge (CK), (4) Technological Pedagogical Knowledge (TPK), (5) Technological Content Knowledge (TCK), (6) Pedagogical Content Knowledge (PCK), and (7) Technological, Pedagogical Content Knowledge (TPCK). In this study, a validated survey was used to measure participants' self-reported TPACK, and qualitative methods were used to located evidence of how participants applied their TPACK in their online special education teaching practice.

High Leverage Practices for SpecEd

The High Leverage Practices (HLPs; see Appendix A) for SETs are a set of 22 evidence-based practices (EBPs) deemed essential for effective SpecEd teaching (Riccomini et al., 2017). The HLPs were developed in 2014 by the Council for Exceptional Children (CEC), one of the leading SpecEd professional organizations in the United States. The CEC received funding from the University of Florida's CEEDAR center (which is itself funded by the U.S. Department of Education) for the development of the HLPs. The HLPs were created by a group of SpecEd experts, based upon a synthesis of existing educational research (McLeskey et al., 2017). The HLPs were primarily conceived of as a guide for helping SET preparation programs develop strong teacher candidates who are able to demonstrate mastery of the fundamental skills involved in SpecEd teaching. However, the HLPs also offer an overall vision of effective SpecEd teaching practice that can aid researchers in better defining this construct.

The list of 22 HLPs are separated into four broad categories that represent the fundamental aspects of SpecEd teaching practice: (1) collaboration, (2) assessment, (3) social/emotional/behavioral practices, and (4) instruction. It is important to note that these categories represent related constructs (McLeskey et al.., 2017). For example, SETs' instructional practices should be informed by reliable student assessment data and should be aligned with student needs and goals identified in an IEP, which is itself developed in collaboration with colleagues, families, and students themselves (especially students who have reached the age of majority). According to Smith & Garret (2021), the HLPs can be adapted for use in online learning contexts.

In the HLPs, the *collaboration* component entails working effectively with general education teachers, instructional aides, related service providers, parents/caregivers, and school administrators in developing and implementing IEPs that meaningfully address students' identified academic, functional and social-behavioral needs. This also entails the ability to organize and lead effective IEP team meetings (McLeskey et al.., 2017). *Assessment* refers to a SET's ability to use both formal and informal data collection methods and instruments to determine students' needs and monitor their progress, as well as to use reliable student performance data to inform instruction (McLeskey et al.., 2017). *Social/Emotional/Behavioral Practices* allow SETs to create safe and nurturing learning environments for all students, to aid in the development of students' social skills and emotional intelligence, and to utilize assessment and intervention strategies to effectively respond to and prevent problem behaviors (McLeskey et al., 2017). *Instruction* refers to the ability to write meaningful individualized goals for students, to deliver specially designed instruction (SDI) that helps students achieve their individualized goals, maintain and generalize student learning, select and implement assistive technology-based interventions, utilize sound pedagogical strategies, and provide students with the modifications, accommodations and supports they need to access the curriculum (McLeskey et al., 2017). In this study, the HLPs are used in defining the construct of effective SpecEd teaching practice and identifying specific practices congruent with this construct.

Purpose Statement

The purpose of this convergent design mixed-methods study is to explore the TPACK and related teaching practices of a sample of SETs working in K-12 online schools in the United States from multiple perspectives in order to both characterize online SET practice in terms of their TPACK, and to identify factors associated with online SET TPACK. More specifically, this study includes a quantitative investigation into the relationship between teachers' measured TPACK and the teacher level variables of age, online teaching experience, education level, and certification status. Additionally, qualitative data reflecting online SET's self-reported teaching practices were analyzed for evidence of specific ways in which online SETs apply their TPACK in their work with students. Lastly, both the quantitative and qualitative data were combined in an effort to identify areas of convergence and/or divergence, as well as for the purpose of locating possible insights related to promising practices in the field of K-12 online SpecEd.

Research Approach

This study used a convergent design mixed-methods approach to investigate the teaching practices and relevant characteristics of a sample of online SETs, through the lens of the TPACK theoretical framework. This approach is appropriate for the study as relying solely on either quantitative or qualitative data would likely yield only a limited understanding of the topic (Creswell & Plano Clark, 2018).

Research Questions

RQ1 (quantitative): What is the relationship between this sample of online SETs' measured TPACK and predictor variables of (1) age, (2) online teaching experience, (3) teacher education level, and (4) teacher certification status?

RQ2 (qualitative): How do participants' responses to the open-ended qualitative items related to their online teaching practices show evidence of their applied TPACK (including their use of high-leverage practices in online settings)?

RQ3 (mixed methods): How do the quantitative and qualitative findings related to participants' TPACK converge and/or diverge?

Sample

The sample for the current study consists of online SETs currently working at secondary (grades 6-12) public and/or charter schools in the United States (excluding territories). The majority of participants worked in fully virtual schools; however, it is possible that some participating SETs provided services for students in supplemental online schools, which are used to provide students in brick-and-mortar schools with access to coursework beyond what is available to them in person. Participants were recruited for the study by sending an email to contacts in a database of secondary online public and charter schools compiled by the researcher using state education websites and other internet search methods. These contacts were then asked to forward the research request and data collection instruments to all online SETs working within their school, district, or organization. However, this recruitment strategy did not generate sufficient data for analysis. Therefore, a database of online secondary SET contacts was created by the researcher, and recruitment emails were subsequently sent out to 881 SET contacts working at over 300 schools in the United States. Ultimately, 46 participants who consented to participate in the study completed at least the demographic and quantitative survey items.

Data Collection and Analysis

Both quantitative and qualitative data were collected concurrently through the administration of an online survey. The quantitative data were collected by administering a validated TPACK self-report instrument (TPACK.xs; Schmid et al., 2020) and collecting relevant information on teacher level variables. The qualitative data were obtained by administering a questionnaire consisting of open-ended items related to participants' online teaching practices, based on the high leverage practices (HLPs) for SpecEd and a review of the current K-12 OLT&L literature. Collecting both qualitative and quantitative data allowed the researcher to gain a better understanding of the general state of online SpecEd teaching practice, online SET TPACK and related variables, as well as more specific information related to the practices being implemented by current online SETs.

Significance of the Study

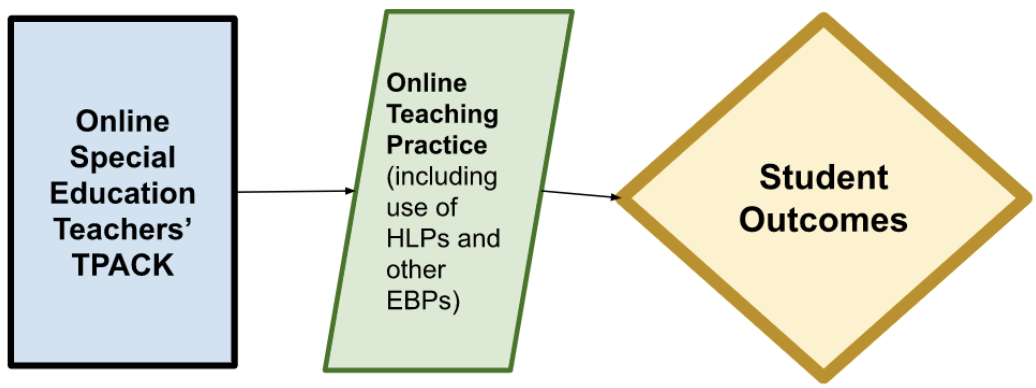
K-12 online or "virtual" schools are increasingly enrolling students with disabilities (SWDs) receiving SpecEd services (Allday & Allday, 2011). Therefore, research related to K-12 online SpecEd practice is urgently needed. The results of this study may contribute to the efforts of K-12 online teaching and learning (OLT&L) researchers, as well as SpecEd researchers, who have begun to validate the use of the TPACK framework in both fields. Furthermore, the results of this study may contribute to the small but growing body of research on K-12 online SpecEd. Findings related to possible "best practices" in online K-12 SpecEd practice may be of benefit to educators working in this growing professional field and may lead to the identification of more specific areas for future research.

A review of the recent K-12 OLT&L and TPACK related academic literature (explored more fully in chapter 2) resulted in the identification of several research gaps that this study is intended to address. To date, relatively few academic research studies have focused on issues related to (1) SpecEd in K-12 OLT&L contexts (Vasquez & Serianni, 2012), (2) TPACK in SpecEd contexts (Courduff et al., 2016), and (3) TPACK in OLT&L contexts (DiPietro et al., 2008), despite the growing need for such research.

Assumptions

The conceptual framework for the current study (see Figure 1) is based on the assumption that online SETs' TPACK informs their teaching practice. In particular, it is assumed that higher levels of TPACK are associated with more effective teaching practices (including the use of HLPs and other EBPs, though perhaps adapted for use in the online learning context). Furthermore, it is assumed that effective teaching practices are those that are most likely to result in positive student outcomes (e.g., academic achievement, satisfactory progress towards IEP goals, high school graduation, increased functional, communication and social skills, etc…).

Figure 1
A Conceptual Framework for the Study



Summary

Given that SWDs requiring SpecEd services and supports are increasingly enrolling in K-12 online schools (Allday & Allday, 2011), there is a need for research that explores K-12 online SpecEd (Thompson et al., 2012), including both the characteristics and practices of K-12 online SETs. Additionally, there is a need for research utilizing the TPACK framework to explore such topics. This convergent design mixed-methods study proposes to make use of the TPACK framework and HLPs for SpecEd to investigate the characteristics and teaching practices of a sample of K-12 online SETs, with the goal of identifying promising practices and future research directions. Ultimately, it is hoped that the findings of the current study may contribute to a body of knowledge that can be used by both researchers and practitioners to improve outcomes for SWDs enrolled in K-12 online public and charter schools.

In Chapter 2, an overview of relevant findings and themes emerging from a review of the recent TPACK and K-12 OLT&L literature is presented, with a special emphasis given to studies exploring these topics in SpecEd contexts. In Chapter 3, more detailed information related to the study's methodology is presented, including a discussion of how data were collected and analyzed for each research question. In Chapter 4, the results of the quantitative, qualitative and mixed-methods analyses are provided. Chapter 5 includes a discussion of the study's findings in reference to previous literature, implications for practice, and possible future research directions.

CHAPTER TWO: LITERATURE REVIEW

This literature review is an attempt to highlight the most important themes emerging from the recent (published within roughly the last decade) K-12 education related academic literature related to both (1) online teaching and learning (OLT&L), and (2) the technological, pedagogical and content knowledge (TPACK; Koehler & Mishra, 2005) framework. In both cases, an effort was made to locate articles related to the education of students with disabilities (SWDs), and/or SpecEd contexts. With respect to the TPACK literature, an additional effort was made to locate articles related to the measurement of teachers' TPACK and the relationship between teacher TPACK and student outcomes (e.g., academic achievement).

A number of relevant search queries were entered into the following databases: (a) Google Scholar, (b) Academic Search Premier, (c) Proquest, (d) JSTOR, and (e) Web of Science, producing a result of more than 300 academic articles. A preference was given to quantitative, qualitative and mixed-methods articles published in peer-reviewed academic journals within the past 10 years, however, some additional articles (e.g., position papers, literature reviews) were included. These articles were deemed to be either (a) seminal publications on the topic (i.e., Harris et al., 2010; Koehler & Mishra, 2005; Koehler & Mishra, 2009; Schmidt et al., 2009; Shulman, 1986), or (b) closely related to this study's research topic (i.e., Marino et al., 2009).

In total, close to 200 articles were reviewed. The K-12 OLT&L literature was reviewed separately from the TPACK literature. The review process consisted of reading through each article and creating an annotated bibliography with information related to research methodology, context, background information, relevant findings, as well as identified research gaps and/or suggestions for future research. Then the annotated bibliography was coded for emergent themes (themes which were recurring or otherwise deemed highly relevant).

The literature review begins by discussing topics related to K-12 OLT&L, in terms of the current state of the field, the affordances and challenges associated with this learning modality, the role of parents/caregivers, and the role of online teachers, including a discussion of teacher characteristics that are relevant to their professional practice. Subsequently, this discussion extends to the field of online SpecEd, and topics specifically related to the education of SWDs in online public and charter schools.

The literature review then contains information regarding certain theoretical frameworks used in K-12 OLT&L research before shifting to a larger discussion of the TPACK framework. Background information on the TPACK framework is provided, as well as a discussion of methods researchers have used to measure teachers' TPACK, and the possible relationships between TPACK and other variables, including (1) gender, (2) teacher age, (3) teaching experience, (3) self-efficacy, and (4) student outcomes. The TPACK literature review concludes with a discussion of recent TPACK related research that has been conducted in SpecEd contexts.

K-12 OLT&L

K-12 students are increasingly enrolling in online (also known as "virtual") schools (Allday & Allday, 2011) a trend that had been accelerating in the years prior to the COVID-19 pandemic, which forced U.S schools to rapidly shift to emergency remote learning in the Spring of 2020 (Gratz et al., 2022). It is worth mentioning here that the COVID-19 pandemic has significantly disrupted both traditional and online K-12 education (Barbour, 2021; Champa et al., 2020), although its long-term impacts are still unknown.

According to a 2021 report by the National Education Policy Center (NEPC), it is estimated that nearly a half-million students in the U.S were enrolled in full-time online and/or blended learning schools (Miron et al., 2021). Although it is difficult to determine the exact number of K-12 SWDs attending online or virtual schools (Basham et al., 2016; Waters et al., 2014; Kumi-Yeboah et al., 2018), it is clear that a growing number of SWDs and their families are choosing the online learning modality (Allday & Allday, 2011; Fernandez et al., 2016; Harris et al., 2020). According to the National Center for Education Statistics (NCES, 2022), approximately 14.5% of all K-12 students have an IEP. Combining this fact with NEPC estimates regarding the number of students enrolled in online schools, it can perhaps be reasonably estimated that approximately 72,000 students enrolled in online schools have IEPs. For this reason, it is necessary for online schools to consider how they will meet the substantive and procedural requirements of the Individuals with Disabilities Education Improvement Act of 2004 (IDEA, 2004), which mandates that students with documented disabilities impacting their ability to access the general education curriculum receive the individualized educational supports and services necessary to ensure access to a free and appropriate public education (FAPE) in the least restrictive environment (LRE). Furthermore, the provision of effective instructional supports to all students enrolled in K-12 online schools is critical for the advancement of educational equity initiatives (Jones & Figueriedo-Brown, 2018). It is therefore imperative that SETs working in online settings implement the most promising instructional practices, which may differ considerably from instructional practices designed for use in the traditional “brick and mortar” classroom context (Tawfik et al., 2021).

According to Barbour (2021), “the first K-12 online learning program was developed by the private school Laurel Springs…around 1991” (p. 919). Since then, there has been a steady growth in online school offerings in the United States (Allday & Allday, 2011), including online primary, middle and high schools. However, most K-12 online students are enrolled in high school (Morgan, 2015). Currently, online K-12 public and/or charter school programs are offered in all 50 states (Kennedy & Archambault, 2012), consisting of schools operated by state education agencies, multidistrict educational management organizations, individual school districts, consortiums and non-profits, and institutes of higher education (Natale & Cook, 2012). Although many online K-12 schools are overseen by state or district level public education agencies, a sizable percentage of these schools are managed by private organizations (Waters et al., 2014). Many such online K-12 schools utilize competency-based curricular programs created by profit seeking third-party vendors (Basham et al., 2016; Greer et al., 2014). While many students enrolled in online schools receive all of their instruction (or at least a majority of instruction) virtually, some supplementary online programs provide students enrolled in brick-and-mortar schools with access to additional educational opportunities or services (Zweig et al., 2022).

According to Martin et al. (2020), the research literature to date indicates that the most successful K-12 online students possess a high degree of self-efficacy and the ability to self-regulate. Similarly, in a meta-analytic study, Rice (2006) found that “independence”, “responsibility”, and “affective abilities” were student characteristics associated with success in online learning contexts. Additionally, technological self-efficacy, organizational skills, and intrinsic motivation, and time management skills have been suggested as important learner characteristics in K-12 online learning environments (Tawfik et al., 2021; Vasquez & Serianni, 2012). It has also been found that K-12 students with higher levels of engagement (as measured by data mining from learning management systems) tend to perform better in their online coursework (Hung et al., 2012).

The recent research literature on K-12 online schooling indicates that some students and parents have chosen to enroll in online learning programs due to problems they experienced in the traditional school setting, often related to a lack of flexibility in scheduling and programming (Jones & Figuerido-Brown, 2018), bullying (Borup, 2016a; Tonks et al., 2021), concerns around physical safety (Rice et al., 2019), health related dangers (Tonks et al., 2021), and/or other emotional-behavioral risks (Coy, 2014). Additionally, traditional high schools are increasingly relying on online learning programs for credit recovery options for students who need to make up coursework required for graduation (Viano, 2018), a fact that is also contributing to recent upticks in K-12 online school enrollment.

Online vs. Traditional Schools

A significant percentage of the research literature on K-12 online schooling to date has focused on comparing student achievement in traditional classroom environments with student achievement in online learning environments (Arnesen et al., 2019; Hu et al., 2019). Overall, the literature shows mixed or inconclusive results regarding the performance of students engaged in online vs. traditional learning modalities (Waters et al., 2014).

Some recent research findings suggest the possibility that students in online school environments tend to perform worse on measure of academic achievement than similarly situated students in traditional school contexts (Morgan, 2015; Tonks et al., 2021; Waters et al., 2014). According to a report by Miron et al. (2014), in 2013, full time virtual schools in the United States were found to have significantly lower Adequate Yearly Progress (AYP) scores than brick and mortar schools. In another study, Thompson et al. (2012) found that among a sample of African American students, and students with significant health needs, those students enrolled in online schools showed lower academic achievement than their counterparts enrolled in traditional schools when comparing for age, gender, race and parent education levels. Additionally, the Center of Research on Educational Outcomes (CREDO) at Stanford University found that eight online charter schools in Pennsylvania performed worse than traditional K-12 schools in the state on measures of academic achievement (Waters et al., 2014). Similarly, Harris-Packer and Segol (2015) compared the available data on math and reading score performance for online K-12 students and students in traditional classrooms in 10 states, finding that these scores were lower on average among online students in eight out of 10 states. Heissel (2016) compared the algebra related achievement of a sample of both online and in-person middle school students, finding that the online students had lower average performance scores. Based on these findings, Heissel (2016) suggested that typically developing middle school students may lack the requisite self-regulation and/or executive functioning skills to be successful in online courses.

In contrast to the research cited above, the recent academic literature on K-12 online learning also contains numerous claims that online schools can in some cases produce better learning outcomes than traditional schools. For example, Means et al. (2013) conducted a meta-analysis of quantitative studies comparing online learning, blended learning, and face-to-face learning modalities, finding that online and blended learning modalities led to higher student achievement on average than did traditional face-to-face instruction, with a mean effect size of 0.2. More specifically, Means et al. (2013) found that the implementation of collaborative and expository instructional techniques had the greatest positive impact on student achievement in online learning contexts, compared to independent (largely asynchronous) activities: This represents a potentially important finding, considering that independent and asynchronous instructional techniques are often regarded as a prime affordance of online learning. The findings of Means et al. (2013) were published by the U.S Department of Education (DOE) in a report that is frequently cited as evidence for the efficacy of K-12 online learning (Waters et al., 2014). However, the majority of the studies reviewed in this meta-analysis were conducted in higher education or adult learning contexts (Means et al., 2013), and were concerned with supplemental online learning rather than full-time online schooling (Waters et al., 2014). In another study, Thompson et al. (2012) found that among a sample of students whose parent(s) had earned at least a bachelor's degree, students enrolled in online schools tended to realize higher academic achievement scores than analogous students in traditional schools.

The recent research literature also contains qualitative accounts from some online K-12 teachers who believe the online learning modality can be more effective and beneficial than traditional schools, at least for some students. For example, Tawfik et al. (2021) found that a sample of online teachers felt that some of their students performed better in online contexts than they had previously in face-to-face classroom environments. In another qualitative study, the majority of sampled online K-12 teachers reported that students showed greater motivation and dedication to their schoolwork, received more individualized supports, and were less involved and/or impacted by bullying in online school contexts (Marteney & Bernadowski, 2016).

Another theme emerging from the recent research literature is that of high performing online schools. According to Ford and Rice (2015), there is growing evidence that certain online schools perform significantly better than other online and traditional schools. Researchers exploring this phenomenon have called for additional investigation into the specific factors, conditions and practices impacting the performance of these exceptional K-12 online schools (Harris-Packer & Segol, 2015).

Overall, the research comparing the effectiveness of online vs. traditional K-12 schools offers inconclusive results. However, some research does suggest that online schools may be getting better over time, gradually leading to average student achievement that is at least on par with that seen in traditional schools (Carnahan & Fulton, 2013). For example, Harris-Packer & Segol (2015) indicate that some states which have been implementing online K-12 schooling for longer periods of time (e.g., Michigan and Florida) now have online student academic achievement scores that are close to the state averages. While the currently available empirical evidence does not support favoring the online learning modality over traditional (or blended) classroom instruction for all K-12 students, there is a growing body of research which suggests that online schools (at least those which can be considered "high performing") may be effective options for certain students, including some SWDs.

Potential Benefits of Online Schooling for SWDs

Several researchers in education have suggested that virtual schools can in some cases provide added benefits for SWDs, when compared to traditional school settings (Allday & Allday, 2011; Corry & Stella, 2012). Numerous potential benefits of online schooling have also been expressed by participants in recent qualitative research on online schooling, including online school administrators, online teachers, parents of SWDs enrolled in online schools, and SWDs themselves (An et al., 2021; Champa et al., 2020; Flores et al., 2018; Marteney & Bernadowski, 2016; Picciano et al., 2012). Additionally, some evidence suggests that many SWDs can achieve good academic outcomes in online school environments (Corry & Stella, 2012), and can "learn and achieve at similar rates as their nondisabled peers" (Allday & Allday, 2011, p. 231).

One key potential benefit of online schooling for SWDs identified in the recent research literature is that of "flexibility" (Allday & Allday, 2011; Champa et al., 2020). Online schools may provide students and families with increased flexibility related to scheduling (e.g., students may be able to schedule virtual sessions with their teachers at times most suitable for them; Marteney & Bernadoaski, 2016), pacing (e.g., students may enjoy flexible deadlines for submitting assignments; Martin, 2016), and location (e.g., many students can complete their schoolwork anywhere that they can access the internet; Morgan, 2015).

Another potential benefit of online schooling for SWDs identified in the recent research literature is increased "personalization" (Coy, 2014; Martin, 2016). In the research on online schooling, “personalization” mainly seems to be achieved by allowing students to work towards mastery of learning standards at their own instructional level (e.g., through a sequential, self-paced online curriculum), whereas in many traditional classroom settings, all students in a grade level classroom would be working on the same instructional materials at the same time (Greer et al., 2014). In one recent study, several online teachers expressed their perception that online schooling allowed them more opportunities to provide 1:1 support to individual students (Crouse et al., 2018), which could also provide a mechanism for increased personalization.

It has also been suggested that online schooling can provide a more sheltered and safe learning environment for certain students who may be at risk of being exposed to various harmful conditions in traditional school environments. For example, online schools may be able to provide protection for students experiencing bullying or peer-related anxiety and depression in traditional school settings (Sorensen, 2019; Borup, 2016a). In one study, Beck et al. (2014) found that SWDs and their parents were more likely than the general student population to cite bullying and/or behavior related problems as reasons for enrolling in online schools. Online schools may also provide a level of protection for students with severe allergic reactions or other significant health issues (e.g., a weakened immune system) that make them vulnerable to environmental conditions found in traditional schools (Martin, 2016; Tonks et al., 2021).

Other potential benefits of online schooling for SWDs identified in the recent research literature include the use of multimedia-based instruction (Martin, 2016; Morgan, 2015), a lack of distractions from peers (Martin, 2016), lack of stigma associated with placement in SpecEd programs (Martin, 2016), increased access to

SpecEd services and programming in rural areas (de la Varre et al., 2014; Martin, 2016), and the provision of continuous feedback based on student performance data (Martin, 2016). Additionally, some K-12 online school administrators have indicated that online schooling is able to provide credit recovery options for students who have failed courses required for graduation and allow students access to courses not offered in traditional schools (Picciano et al., 2012).

Challenges Related to K-12 Online Schooling

Although K-12 online education in its current and future forms may offer numerous potential benefits to SWDs and their parents/caregivers, the recent academic literature also has exposed a number of challenges related to online schooling (Hashey & Stahl, 2014). Morgan (2015), acknowledging the benefits and affordances of K-12 online learning, cautions that the online learning modality may also impede the academic achievement of certain at-risk students, including SWDs.

One major challenge identified in the recent research literature is related to a perceived difficulty engaging some online students in school activities (Ames et al., 2021). According to Borup (2016b), online school administrators often list low levels of student engagement as a primary challenge they encounter in their work. Borup et al. (2014b) found that a sample of online teachers found it difficult to engage "reluctant" students, which they attributed to the perceived physical separation inherent in online learning, and a lack of visual cues (e.g., eye contact, facial expressions) which would generally be present in traditional school settings. Marteney and Bernadowski (2016) found that a sample of online teachers reported feeling that their students did not engage sufficiently with the online learning resources provided to them. Additionally, some students have expressed feeling that their online coursework was not personally relevant to them (Barbour et al., 2013), or did not adequately relate to or reflect their cultural background (Kumi-Yeboah et al., 2018), which may partially explain some of the challenges online schools have faced related to student engagement.

Both online teachers and students featured as participants in the recent research literature have expressed feeling a sense of isolation, and a lack of meaningful interpersonal connection and collaboration in online learning contexts (Barbour, 2022; Tonks et al., 2021). According to An et al. (2021), teachers who shifted to online learning in the Spring of 2020 due to COVID-19 related school closures were specifically challenged by the lack of face-to-face interaction with students. However, it should be mentioned here that emergency remote teaching due to COVID-19 relate school closures cannot be directly compared to normal online schooling, where teachers and students have time to develop effective procedures and expectations and acclimate themselves to teaching and learning in the online environment (Martin et al., 2022). Crouse et al. (2018) found that a sample of online teachers desired more communication and collaboration with other online teachers, while Morgan (2015) found that some online teachers experience a feeling of alienation attributable to a lack of nonverbal communication and/or meaningful collaboration with colleagues. In one qualitative study, Barbour (2013) reported that two secondary online students expressed feeling that their online course provided little opportunity for interpersonal interaction. Barbour (2022) found that a sample of online students felt little sense of community with their peers. Borup et al. (2014a) connected this sense of isolation and lack of community to students' failure to persist in online coursework. Furthermore, Kumi-Yeboah et al. (2018) found that a lack of social presence in online courses negatively impacted online K-12 students' academic self-concept.

Perhaps not surprisingly, the recent research literature on K-12 online learning contains numerous descriptions of technological challenges faced by teachers, students, and parents (Martin, 2016; An et al., 2021). Ames et al. (2021) report that some online teachers reported certain challenges associated with students' technological knowledge and skill deficits, as well as students' motor deficits needed for effectively using computers (e.g., difficulty with typing, and/or mouse/keyboard control). Additionally, a sample of online teachers reported the need for contingency plans in the event of technological failures (e.g., internet outage, hardware malfunction; Ames et al., 2021). Some online teachers have also expressed their own personal challenges related to learning new technologies (An et al., 2021). Furthermore, some students continue to lack reliable access to internet connected devices needed for participation in online learning activities (Barbour, 2013), a problem which was clearly exposed with COVID-19 school related closures (An et al., 2021).

The research literature has also indicated certain challenges related to commonly used curricular materials in existing K-12 online learning programs. Borup et al. (2014a) stated that a lack of clear instructions on assignments can contribute to students' failures to persist in their online coursework. Some students and parents have also reported their perception that online programs require an excessive amount of student work (Barbour, 2013), a problem potentially compounded for students with more significant disabilities (Rice et al., 2019). Additionally, the competency or mastery-based approach to learning that is often used in K-12 online environments is not always suitable for SWDs who may require more individualized instruction and/or extra supports to complete assigned activities (Greer et al., 2014). However, Crouse et al. (2018) also found that teachers' expectations that students would attend regular 1:1 and/or small-group synchronous instructional sessions may sometimes lead to frustration in students who expect more scheduling and pacing flexibility and choice in the online school.

Some recent research supports the claim that online teaching is more challenging and demanding than traditional classroom teachers or pre-service teachers initially believe it to be (Jackson & Jones, 2019). According to Tonks et al. (2021), online K-12 teachers often need to contend with large caseloads of students, a perceived lack of parent/caregiver support, and a lack of "best-practice" guidelines. Borup et al. (2016a) found that a sample of online teachers struggled to find the balance between self-paced and flexible (largely asynchronous) online learning, and the need to provide more intensive instruction to struggling students and/or to incorporate interaction and collaboration in online coursework. Additionally, research conducted through the Center on Online Learning and Students with Disabilities (COLSD) found that online teachers of SWDs often struggled to find and utilize "appropriate accommodations to support diverse learning needs presented in the blended and virtual environments" (p. 80, Greer et al., 2014). Crouse et al. (2018) found that transitioning from traditional to online school was challenging for teachers, who benefitted from interaction with, and guidance from, experienced online mentor teachers. Ames et al. (2021) found that a sample of online teachers faced challenges in finding effective professional development offerings related to the online learning context. This is particularly concerning given the urgent need for teachers to be trained in providing specially designed instruction (SDI) to SWDs in the context of online schooling (Martin, 2016).

Preventing student attrition and dropout has been identified as another major challenge for K-12 online schools (Waters et al., 2014). According to Borup et al. (2014a) many K-12 online school administrators estimate the online learning attrition rate to be as much as 20% higher than brick-and-mortar schools. In corroboration, Borup and Stevens (2017) write that "there is increasing evidence that adolescent students who enroll in online courses experience higher attrition rates…than students experience in comparable face-to-face environments" (p. 1119). De le Varre et al. (2014) found that a sample of students who had dropped out of their online programs attributed their own failure to persist to one or more of the following factors: (1) scheduling and/or time constraints, (2) excessive academic demands of their online courses, (3) lack of motivation, (4) technological difficulties and deficits, (5) a perceived lack of teacher immediacy, and (6) influences from their parents/caregivers. Notably, Higashi et al. (2017) indicated that middle and high school students' relevant prior knowledge (as measured by pre-test scores) and expressed interest in the subject matter predicted persistence in online courses.

Other challenges related to K-12 online schooling identified in the research literature include conducting teacher observations for evaluation purposes (Sorensen, 2019), the implementation of response to intervention (RTI) services (Sorensen, 2019), tracking attendance (Morgan, 2015), identifying and responding to student truancy (Archambault et al., 2013) and academic dishonesty (Morgan, 2015), protecting students (particularly SWDs) from cyberbullying (Martin, 2016), negative teacher candidate perceptions about K-12 online learning (Rakes & Dunn, 2015), and a perceived lack of accountability for some online schools (especially online charters; Natale & Cook, 2012; Ortiz et al., 2021; Waters et al., 2014). Despite the challenges identified, it is clear that online schools must be prepared to provide appropriate educational services and programming for SWDs (Love & Ewoldt, 2021).

Legal and/or Ethical Challenges

K-12 online schools face additional challenges related to meeting the legal requirements of IDEA (2004), such as implementing positive behavior supports and interventions, and providing students with related services such as occupational therapy and physical therapy (Martin, 2016). Similarly, certain ethical challenges related to the provision of services within online schools were identified in the recent research literature. Although some qualitative evidence indicates that certain K-12 online public and charter schools are effectively navigating such challenges (Sorensen, 2019), it appears that at present there is no agreed-upon roadmap or list of best practices that schools can uniformly implement to fulfill both legal and ethical obligations.

Basham et al. (2016) identified compliance with the IDEA (2004) least restrictive environment (LRE) mandate as a particular legal challenge for K-12 online schools. The LRE principle states that SWDs should be educated alongside their nondisabled peers to the maximum extent possible, with preference given to the general education classroom as an educational placement. There is some disagreement as to whether enrollment in an online school constitutes a change of placement to a more restrictive environment for SWDs, and whether a new evaluation or IEP should be developed before such a change in placement occurs (Basham et al., 2016). It is important that online schools take into account LRE considerations when enrolling SWDs, especially given that some judges have demonstrated a tendency to view online schools as more restrictive educational placements (Martin, 2016). Similarly, given the proliferation of online public and charter schools that enroll students from outside of normal school district boundaries (and in some cases, even out of state), it is important that online schools determine which agency will be responsible for providing FAPE for students with IEPs (Basham et al., 2016).

Another legal concern relates to the basic enrollment procedures for SWDs in online schools. In recent years, some K-12 online public and charter schools have denied students admission on the basis of their disability, a practice out of compliance with federal law (Ortiz et al., 2021). According to Carnahan and Fulton (2013), despite the fact that online school placements may not be ideal educational placements for all SWDs, students should retain access to online learning opportunities irrespective of their disability status. However, Martin (2016) contends that if K-12 online schools were to implement open enrollment policies, some may find themselves unable to comply with the substantive requirements of IDEA (2004), especially FAPE.

In addition to the aforementioned legal concerns and challenges related to K-12 online schooling for SWDs, several ethical concerns were located in the recent research literature, especially related to concerns around improper uses of state funds by online charter operations (Waters et al., 2014). These concerns are related to the more general trend of introducing market forces into public schooling, wherein for-profit companies are increasingly being tasked with providing fundamental educational services (Darling-Aduana, 2021). In some cases, there are concerns that cost cutting measures associated with profit seeking could reduce the quality of online students' education (Wright &

Peters, 2017). In one instance, the large online school curriculum and educational service provider K-12 Inc. was found to have contracted instructional services from lower payed teleworkers in India, eschewing higher paid, state-certified educational professionals in the United States (Natale & Cook, 2012; Waters et al., 2014).

The Role and Impact of Parents/Caregivers in K-12 Online Schooling

The recent research literature contains numerous references to ways in which parent/caregiver (hereafter referred to as "parent") roles differ in online and traditional K-12 school contexts. It has been claimed that parents assume additional responsibilities related to their child's education in K-12 online learning contexts (Tawfik et al., 2021). This may be particularly true for SWDs who may require additional support to benefit from and succeed with online instruction (Ortiz et al., 2021; Sorensen, 2019; Tonks et al., 2021). In fact, according to Waters et al. (2014), online K-12 schooling in its current form may place an excessive burden and unrealistic time commitment on many parents. Nonetheless, it is essential to understand and define the roles and responsibilities of parents of SWDs enrolled in online schools, as parents of SWDs are becoming more interested in online school options (Marteney & Bernadowski, 2016).

The recent research literature also contains descriptions of teachers' expectations for parents in the online school setting. For example, Borup (2016b) found that among a sample of K-12 online teachers, a majority of participants expressed the belief that parents had a responsibility to help motivate their students to complete their online coursework, especially when concerns related to adequate student performance were present. However, Borup (2016b) also found that these teachers expressed a preference for parents who were "moderately" engaged in their child's online education, suggesting that a lack of parental engagement and excessive parental engagement could both negatively impact student learning. Additionally, these online teachers suggested that parents of students previously enrolled in traditional schools often struggled to engage sufficiently in their child's online schooling, while parents who had previously homeschooled their children found it difficult to adapt to the less controlling role of "facilitator" (Borup, 2016b). Tawfik et al. (2021) also found that a sample of online teachers described efforts to engage and utilize parents to facilitate online learning as a regular part of their teaching practice. However, over 40% of parents sampled by Borup et al. (2013) reported having no interaction with their student's online teachers.

The recent literature contains support for the assertion that some parents may be lacking in the technological, content-area, and/or pedagogical knowledge needed to effectively facilitate their child's engagement with online learning. According to Ames et al. (2021), online K-12 teachers should be able to teach technology related skills to parents. Borup (2016b) found that a sample of teachers felt that some parents were particularly ill-equipped to provide support to their students in math and science related coursework. In one qualitative case study, a foster parent of a SWD enrolled in online school described her struggles to learn new technologies needed to facilitate her child's engagement in online learning (Rice et al., 2019). However, the foster parent also believed that her college education had given her some of the skills she deemed necessary for facilitating her child's online learning (Rice et al., 2019). Fernandez et al. (2016) found that among a sample of K-12 online students, those whose parents had obtained at least a bachelor's degree experienced better academic achievement than other students. However, this phenomenon is likely not unique to online school contexts, as other studies have found statistically significant impacts of parent education levels on student achievement in traditional school settings (Petty et al., 2013). Interestingly, Thompson et al. (2012) found that among their participant sample, parents of K-12 students enrolled in online schools were more likely to have a college degree than parents of students in traditional schools.

Another theme identified in the recent research literature relates to parent satisfaction with the online school experience of their children, especially with respect to the provision of SpecEd services. Beck et al. (2014) found that among a sample of parents of students enrolled in online schools, parents of students receiving SpecEd services were more satisfied with the online school experience than were other parents. Similarly, in their survey of a sample of parents of SWDs, Ortiz et al. (2021) found evidence that these parents were generally satisfied with the services provided by their student's online schools. However, Hinderliter et al. (2021) found that a sample of parents whose students had experienced emergency online learning during the COVID-19 pandemic expressed dissatisfaction and anxiety with their students' online school experience. Hinderliter et al. (2021) suggested that this parental dissatisfaction was related to student skill deficits in executive functioning and self-regulation, which may be crucial for success in online learning modalities. In another study, Rice et al. (2019) found that a foster parent of a SWD felt overwhelmed by what she perceived as the excessive instructional demands placed on her by the online school, even as she tended to express overall satisfaction with the efforts of school staff.

Overall, the research literature makes it clear that parents of SWDs enrolled in online schools tend to assume new responsibilities related to providing technological, instructional and motivational support (Borup et al., 2013), relative to their parental roles in traditional schools. In the same vein, online teachers of SWDs have the added responsibility of engaging parents (Borup, 2016b), providing them with the knowledge and skills they need to effectively facilitate online learning for their students (Ames et al., 2021), and ensuring that expectations related to parental roles and responsibilities are reasonable and manageable.

The Role of K-12 Online Teachers and "Best Practices" in Online School

A number of the research articles reviewed were concerned with online teacher roles and responsibilities, relevant characteristics, and/or "best practices" in online teaching. For example, in a qualitative study aimed at defining best practices in K-12 OLT&L, DiPietro et al. (2008) interviewed 16 online teachers they had identified as "successful", based on a minimum of three years of online teaching experience, and full professional teacher licensure. According to DiPietro et al. (2008), successful virtual teachers (1) used a variety of assessment methods to obtain actionable student performance data, (2) were flexible in scheduling meeting times with students, (3) provided all students with individualized feedback, (4) made efforts to establish a social presence in their online courses (e.g., logging in regularly to the LMS, checking in with students, and providing quick feedback and responses to students), (5) established clear expectations related to student behaviors, (6) monitored student communications to identify struggling students and/or students in crisis, (7) provided students with multiple avenues for expressing their knowledge, (8) incorporated student interests into instruction, (9) collaborated well with other school staff, (10) worked to establish strong relationships with students (e.g., by discussing non course-related topics), (11) structured course content in a logical and user-friendly format, (12) used specific strategies to motivate students (e.g., by establishing deadlines for self-paced assignments), (13) differentiated course content to accommodate diverse learners, (14) provided students with supplemental instructional materials and resources, (15) frequently engaged in progress monitoring of student performance, and (16) demonstrated professionalism and warmth in all their interactions.

In another qualitative study, Borup and Stevens (2017) investigated the preferences of a sample of online K-12 students with respect to their teachers' instructional practices. Borup and Stevens (2017) found that this sample of online students preferred when their teachers (1) made efforts to become individually acquainted with them (e.g., through a beginning of the year survey), (2) demonstrated excitement about the content, (3) provided students with choices related to their assigned work, (4) allowed students to engage in creative activities (e.g., making a video to demonstrate their knowledge), (5) found ways to make the content relevant to students' lives, (6) closely monitored student performance and behavior in the course, and (7) provided students with public praise for their hard work. Alternatively, these students did not prefer when teachers (1) demonstrated stiffness or excessive formality in their interactions and communications with students, (2) did not provide quick feedback and/or responses to students, (3) assigned activities that students perceived to be "busy work" (e.g., repetitive tasks).

Several articles reviewed attempted to define promising practices online teachers can implement to benefit SWDs, and/or promising practices in the delivery of SpecEd services. For example, Kim and Fienup (2021) were able to show increases in students' work-related engagement in online learning after providing three elementary aged SWDs and their families a daily schedule with five assignments, and reinforcement contingent upon students' completion of the assigned work. This finding was consistent with previous research demonstrating the efficacy of task analysis-based interventions for SWDs in traditional school environments (Kim & Fienup, 2021).

Tonks et al. (2021) state that online schools may be required to adapt their curricular materials to effectively meet the needs of SWDs. According to Greer et al. (2014), online teachers can sometimes meet the unique needs of SWDs by providing them access to digital supplementary instructional materials such as "BrainPOP", a website which contains animated instructional videos, engaging digital activities and assessments covering several different content areas (Martin, 2017).

Sorensen (2019) used qualitative methods to analyze the reported and observed practices of nine SETs working in virtual schools in the state of Idaho. Sorensen (2019) found that this sample of online SETs used the following strategies to provide legally compliant SpecEd services to SWDs in online contexts: (1) providing 1:1 and/or small-group synchronous instruction, (2) coordinating teletherapy for related services, (3) utilizing and supporting parents as facilitators for online learning, (4) providing extra individualized instruction and teletherapy for students with greater needs, especially younger learners, (5) working to build strong relationships with students and parents, and (6) helping provide students and parents with access to needed technologies, as well as technology related training when appropriate.

In one qualitative study, Spitler et al. (2013) interviewed the CEO of an online charter school with a significant (15%) number of students receiving SpecEd services.

The researchers documented how aspects of the "5 Cs framework" (connect, climate, control, curriculum, and caring community) could be used to help increase graduation rates for SWDs in online schools. According to Spitler et al. (2013), the online charter school was able to effectively serve their SWDs by (1) encouraging students and families to fully participate in IEP meetings, (2) connecting current student learning to individualized postsecondary goals (aligned with student transition plans beginning in 9th grade), (3) establishing a supportive learning environment, (4) incorporating student interests into learning activities, (5) frequently monitoring student progress towards IEP goals, (6) considering, and responding to, students' non-academic needs, (7) modifying curriculum and/or utilizing alternative curricular materials when necessary, and (8) planning and facilitating occasional in-person activities - a practice also suggested by other researchers (Barbour, 2022; Coy, 2014).

In addition to the research articles reviewed above, several non-research-based articles were located which documented what the authors considered effective online SpecEd teaching practices. For example, Coy (2014) stated that online SETs should ensure that SWDs are aware of their own individualized goals, and that older students participate in the creation of their IEP goals as much as possible. Coy (2014) also emphasized the importance of online teachers utilizing parents as "learning coaches" tasked with implementing IEP accommodations in the home.

In another non-research based article, Love and Ewoldt (2021) put forward a four step process that online teachers can use when planning instruction for SWDs: (1) break down IEP goals and/or learning standards into discrete learning objectives, (2) list the units, lessons and topics in the curriculum where these learning objectives are addressed,

(3) evaluate the appropriateness of the curricular resource for use with SWDs (the authors provide a graphic organizer for this purpose), and (4) locate supplementary resources that can address any criteria found lacking in the general curriculum. Furthermore, Love and Ewoldt (2021) recommend that online teachers utilize instructional materials that promote the active engagement of SWDs during the modeling and guided practice phases of direct instruction. Additionally, online teachers should choose instructional resources that are user friendly, easy to navigate, and accessible for SWDs (Love & Ewoldt, 2021). Love and Ewoldt (2021) also emphasize that selected instructional tools should allow for reliable measurement of students' progress. When teachers are not able to locate adequate resources for use with SWDs, they may consider creating such resources themselves (Love & Ewoldt, 2021).

Teacher Knowledge, Skills and Characteristics

It has been suggested that online teaching requires a skill set and knowledge base distinct (but related to) that required for traditional classroom instruction (Corry & Stella, 2012; Tonks et al., 2021). For example, Borup and Stevens (2017) indicate that strong communication skills (including text-based communication) are required for online teaching. According to Pulham and Graham (2018), K-12 online teachers require greater instructional design skills than do teachers working in traditional and/or blended learning contexts. Pulham and Graham (2018) also state that online teachers should be skilled in facilitating online discussions (e.g., on asynchronous discussion boards).

In their investigation of the practices of "successful" online K-12 teachers, DiPietro et al. (2008) found that these teachers had strong organizational skills, utilized routines effectively, and frequently accessed student performance data to inform their instruction. Additionally, it was found that successful online teachers possessed strong content knowledge, recognized and appreciated the affordances of online learning, and possessed strong basic technological skills (DiPietro et al., 2008). DiPietro et al. (2008) also found that successful online teachers based their technology integration decisions on their content knowledge, and knowledge of students, and were interested in exploring the use of new innovative technologies in their teaching practice.

According to Crouse et al. (2018), the research literature to date indicates that online teachers should possess several distinct skills in order to work effectively with SWDs. The researchers suggest that online teachers should be able to (1) monitor student progress regularly, (2) offer students effective instructional strategies, (3) assist students in learning new vocabulary and accessing text, (4) encourage the development of students' social skills and provide opportunities for meaningful peer to peer interaction, and (5) advocate for accessible instructional materials (e.g., with vendors, course designers, administrators; Crouse et al., 2018).

Some researchers have also suggested that online teachers may be more likely than traditional brick-and-mortar teachers to believe in the importance of catering to students' different "learning styles" (e.g., visual, auditory, kinesthetic; DiPietro et al., 2008), a concept that many educational researchers have rejected (Beasley & Beck, 2017). According to Beasley & Beck, this may be explained by the specific inclusion of language related to "learning styles" in the iNacol (2010) online teaching standards.

<u>K-12 Online Learning Curriculum</u>

According to Natale and Cook (2012), the majority of online learning is asynchronous (students work at their own pace), although synchronous instruction (e.g., teachers presenting instruction in real time to students via video conference) is also not uncommon. Tonks et al. (2021) state that the majority of K-12 online learning curriculum is provided by private 3rd party vendors. Multimedia instructional resources (e.g., audio, video, animation) are often employed in K-12 online learning settings, however, there is some evidence that such media can serve as distractions if not closely related to specific learning objectives (Zheng et al., 2020).

Darling-Aduana (2021) evaluated online school curricular resources used by a large urban school district in the United States, and concluded that the majority of the content targeted low level skills such as basic memorization through the use of true/false and/or multiple choice questions, and did not include much in the way of the kind of "authentic work" that can develop students higher level skills (e.g., critical thinking). Although this finding cannot be generalized across all K-12 online schools, it does raise some concerns as to the quality of existing K-12 online learning curricular resources.

"Interaction" in K-12 Online Schools

The concept of "interaction" emerged as another theme in the recent research literature on K-12 online learning. Interaction refers to the facilitation of communication and collaboration between students, teachers, parents, and other relevant parties in online learning contexts. Interaction is an important concept in OLT&L as learning occurs generally as a result of interactions between the learner and some other source of information and/or feedback. Moore (1989) developed an interaction framework which has served as a foundation for many subsequent studies. Moore (1989) distinguishes between three types of interaction: (1) interactions between learners and content, (2) interactions between learners and instructors, and (3) learner to learner interactions.

Moore (1997) also developed the concept of “transactional distance”, which refers to “psychological and communications space” (p.22) that must be traversed by learners and instructors in distance education contexts, including in K-12 OLT&L.

Borup et al. (2014a) investigated the impacts of course-related interactions on a sample of online high school students’ grades, perceived learning, course satisfaction, and disposition towards the subject area. It was found that the majority of students perceived all three of Moore’s (1989) types of interaction to aid their motivation and learning. However, learner-instructor interactions were perceived to be the most educationally valuable, while learner-learner and learner-instructor interactions were perceived to be more motivational than learner-content interactions (Borup et al., 2014a). In another study, Borup et al. (2013) found that students perceived learner-parent interactions related to their online coursework to be motivating, even more so than did their parents.

Interestingly, Borup et al. (2014a) found that learner-learner interactions were positively correlated with final course grades, while learner-content and learner-instructor interactions were not. Similarly, Hawkins et al. (2013) found no significant correlation between learner-instructor interactions and final grade, however a significant correlation was observed between learner-instructor interaction and course completion. It is possible that learners who are generally more engaged in the course earned higher final grades and engaged in more learner-learner interactions than other students. Borup et al. (2014a) also cautions that the findings related to learner-instructor interactions and student performance outcomes may be skewed as learner-instructor interactions can often be instigated by concerns over student performance.

In another study related to interaction, Borup (2016a) explored a sample of online teacher perceptions related to learner-learner interactions. These teachers indicated that they believed the facilitation of learner-learner interactions in online schools was an important factor for increasing student motivation and achievement (e.g., through peer-to-peer tutoring), however they also felt that excessive learner-learner interaction (especially social rather than course related interaction) could get in the way of student achievement, and sometimes even led to instances of cyber-bullying (Borup, 2016a). This perception aligns well with the Community of Inquiry (COI; Garrison et al., 2000) framework, in which it is generally acknowledged that excessive "social presence" not related to course material can distract from learning in online contexts.

Overall, the research literature suggests the importance of achieving optimal levels of learner-learner interaction in online schools (Ames et al., 2021; Borup, 2016a). However, according to Tonks et al. (2021), many existing K-12 online learning programs may not include adequate access to extracurricular activities or facilitate sufficient levels of learner-learner interaction. In fact, in their national study of online charter schools, Gill et al. (2015) found that among a sample of online charter high school administrators, only 21% reported using collaborative learning strategies (which rely on learner-learner interactions).

"Engagement" in K-12 Online Schools

The recent research literature on K-12 online learning includes a number of references to the concept of "engagement". Engagement generally refers to the ways in which students actively participate in online school activities. According to Harris et al. (2020), there is no single agreed upon definition of student engagement, however, the majority of the research literature on this topic makes use of the model proposed by Fredricks et al. (2004). According to this model, student engagement is broken down into three types: (1) behavioral engagement, (2) emotional engagement, and (3) cognitive engagement (Fredricks et al., 2004).

Harris et al. (2020) conducted a qualitative study exploring student engagement strategies used by a sample of 16 online teachers in Australia. The researchers found that the online teachers generally defined engagement in terms of its behavioral or emotional, as opposed to cognitive, components (Harris et al., 2020). Additionally, these teachers reported challenges related to measuring student engagement in online contexts (Harris et al., 2020). The teachers believed these challenges were exacerbated by the lack of visual cues on student behavior available to teachers during synchronous instruction (Harris et al., 2020).

In another study, Louwrens and Hartnett (2015) used qualitative methods to explore the engagement of a sample of 10 online middle school students in New Zealand. The researchers found that both teachers and students perceived that the inclusion of learning activities outside of the learning management system (LMS) increased student engagement, which the teachers attributed to the ability for students to exercise greater choice and control than was typically possible on assignments contained completely within the LMS (Louwrens & Hartnett, 2015). Both teachers and students also identified teachers' efforts to build positive relationships with their students (e.g., developing a safe learning environment in which teachers and students can interact and build a positive social presence) as a factor promoting increased student engagement (Louwrens & Hartnett, 2015). Again, both teachers and students perceived that task and process-oriented teacher feedback focused on building students' self-esteem and academic self-confidence helped to increase student engagement (Louwrens & Hartnett, 2015). Additionally, students reported that learning activities which were related to their personal interests, relevant to their lives, and which they perceived as fun, promoted their behavioral, emotional and cognitive engagement (Louwrens & Hartnett, 2015).

Universal Design for Learning (UDL), Assistive Technology, and Accessibility

Universal Design for Learning (UDL), assistive technology (AT), and accessibility all appear as important related themes in recent academic literature concerned with the instruction of SWDs in online settings (Love & Ewoldt, 2021). UDL has been recognized as an important framework that can guide teachers as they locate, evaluate, adapt, create and implement instructional materials that are accessible to all students, including SWDs. Developed by CAST (an education research and development non-profit organization) in the early 2000s, the UDL framework states that instructors and curriculum designers can accommodate predictable differences among students by making use of three principles during instructional development and implementation: (1) multiple means of engagement (how students interact with learning materials), (2) multiple means of representation (how content is presented to students), and (3) multiple means of action or expression (how students are assessed, or how students share what they have learned; Meyer et al., 2014). In the context of K-12 education, AT refers to the selection and utilization of low-tech or high-tech tools and related services to help SWDs access the general education curriculum, communicate and interact socially, and engage in extracurricular activities (Allen et al., 2009). Accessibility in education refers to the degree to which a physical or online environment is able to be utilized by a diverse set of learners, including SWDs (Shaheen & Watulak, 2018).

In one study guided by the UDL framework, Smith and Harvey (2014) found that Khan academy lessons (widely used in online and blended learning) were not closely aligned to the principles of UDL, despite including accessibility features such as closed captioning and embedded text-to-speech software. In particular, the researchers found the Khan Academy lessons lacking in multiple means of action and expression (Smith & Harvey, 2014). The researchers concluded that Khan academy lesson materials used in isolation are not adequate instructional resources for many SWDs (Smith & Harvey, 2014).

Challenges related to locating fully accessible instructional materials for SWDs in online settings goes well beyond Khan Academy, as many instructional designers creating online learning resources may not be familiar with the principles of UDL (Tonks et al., 2021). According to Smith and Harvey (2014), online teachers cannot solely rely on a curricular resources' alignment to common core standards in determining its suitability for use with SWDs. Furthermore, it is not sufficient to rely solely on information provided by curriculum vendors (Smith & Harvey, 2014). For these reasons, it may be necessary for SETs to locate, adapt and/or create customized instructional tools and assistive technologies for their online SWDs (Love & Ewoldt, 2021).

Professional Development and Teacher Preparation for K-12 OLT&L

Another theme emerging out of the recent K-12 OLT&L research literature is related to the preparation and professional development of in-service teachers (ISTs) and pre-service teachers (PSTs) working in online contexts (Hu et al., 2019). In one qualitative study, Crouse et al. (2018) found that teachers reported that professional development opportunities offered through their employers were a major source of knowledge informing their online teaching practice. DiPietro et al. (2008) found that “successful” online teachers continuously looked for professional learning opportunities to build their content knowledge, technological knowledge, and overall teaching practice. Although it is generally accepted that online teachers should regularly engage in professional learning activities related to their teaching assignments (Flores et al., 2018), there is still a need for a greater number of high-quality online teacher training resources (Jackson & Jones, 2019). More specifically, Rice (2017) found that there were insufficient professional development opportunities available for online teachers related to their work with SWDs (Crouse et al., 2018).

The research literature also contains numerous references to online teaching preparation for PSTs (Hu et al., 2019). For example, Jackson and Jones (2019) used qualitative methods to examine the experiences of four PSTs enrolled in an online teaching preparation program, reporting that the PSTs felt that virtual field experiences had significantly improved their online teaching abilities. Similarly, Luo et al. (2017) found that PSTs exposed to K-12 online learning contexts (e.g., through virtual field placements) improved their perceptions about the potential efficacy and benefits of online learning. Additionally, Hall et al. (2021) stated that virtual field placements could allow for “reverse mentorship” opportunities, in which PSTs helped their mentor teachers adapt to their online teaching roles (e.g., by providing technological support). Despite the potential benefits of virtual field placements and online teacher preparation programs (Kennedy et al., 2013), Champa et al. (2020) found that the majority of teachers who were expected to transition to emergency remote teaching in the Spring of 2020 due to COVID-19 related school closures had experienced no online teaching or distance learning related training in their teacher preparation programs. Similarly, Crouse et al. (2018) used qualitative methods to explore the experiences of six online charter school teachers in the U.S, finding that this sample of teachers had not received any training or preparation directly related to online teaching, but instead had to rely upon skills they learned on the job. More specifically, according to Smith et al. (2016) SET preparation programs should include more OLT&L programming, especially on issues related to assessment and instructional design.

K-12 OLT&L Theoretical Frameworks

A number of different theoretical frameworks have been used to guide some of the recent K-12 OLT&L research. For example, Moore's (1989) aforementioned interaction framework has been used extensively by researchers such as Jered Borup (Borup et al., 2014a). Borup et al. (2014a) also developed the Adolescent Community of Engagement (ACE) framework for use in K-12 online learning contexts (Borup, 2016a; Borup & Stevens, 2017). Additionally, the Community of Inquiry (COI) framework (Garrison et al., 2000) has been used to guide research on teaching presence, social presence, and cognitive presence in online learning contexts for both higher education and K-12 online learning contexts (Borup et al., 2014; Martin et al., 2020). Additionally, the previously discussed UDL framework has been used in several studies specifically related to K-12 online SpecEd (Love & Ewoldt, 2021; Smith & Harvey, 2014; Tonks et al., 2021).

The TPACK framework has also been used to guide research on K-12 OLT&L. For example, it has been used to measure online teaching skills (Archambault & Crippen, 2009), and to guide a literature review on effective online teaching practice (Moore-Adams et al., 2016). Ames et al. (2021) advocated using the TPACK framework as a lens through which to view online teaching knowledge and skill, while Ward and Kushner-Benson (2010) advocated for the use of the TPACK framework in the development and implementation of online teacher training. According to Basham et al. (2013), TPACK offers a solid lens through which to view teachers' technology integration practices, however, "a more complete solution is needed for advancing teacher skill development required for current…virtual classrooms" (p. 56) Despite such criticisms, several researchers have indicated that the TPACK framework can be used to effectively investigate K-12 OLT&L in both general and SpecEd contexts (Ames et al, 2021; DiPietro et al., 2008; Ward & Kushner-Benson, 2010). Given that the TPACK framework is being used to guide the current study, a more comprehensive review of the framework and recent related literature in K-12 education contexts is provided below.

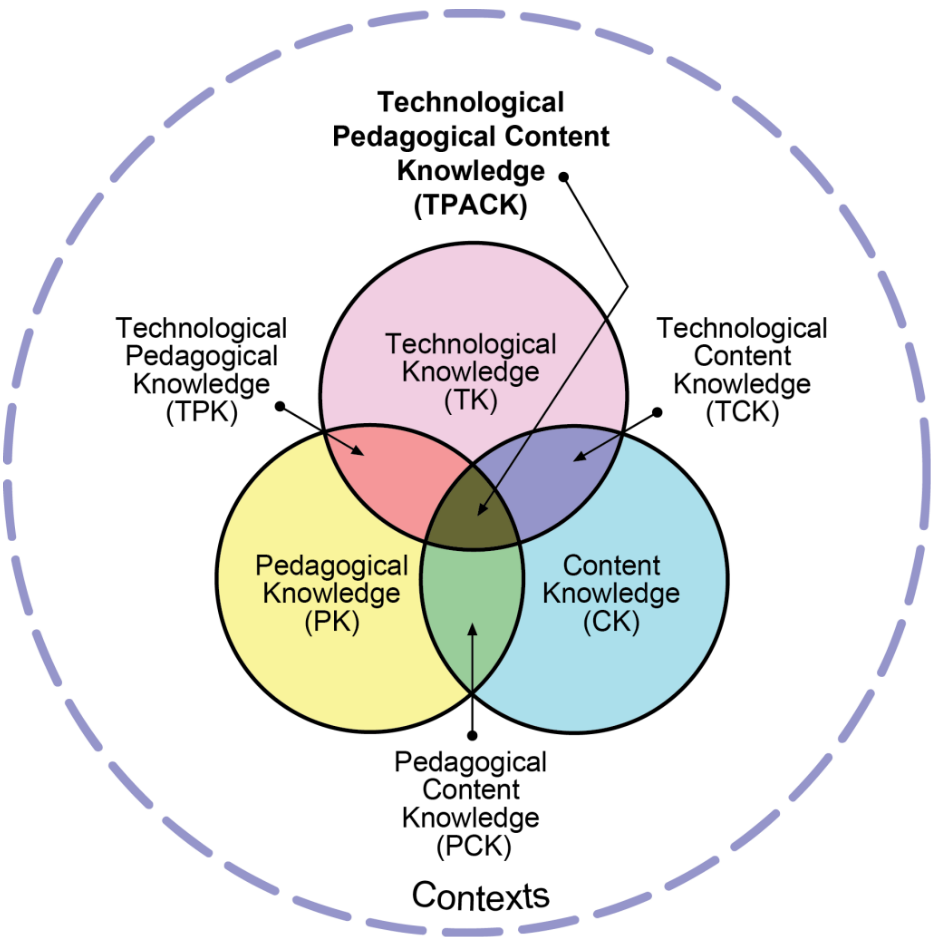
TPACK

The TPACK framework was introduced by Koehler and Mishra (2005) as a way of conceptualizing the kinds of knowledge teachers require in order to effectively integrate technology into their instruction. The TPACK framework builds upon the work of Shulman (1986), who argued that educational researchers had become overly focused on pedagogical strategies and were insufficiently concerned about teachers' content knowledge. Shulman (1986) felt that high quality teaching practices were products of teachers' *Pedagogical Content Knowledge* (PCK), which included not only teachers' subject matter expertise, but also their knowledge of how to best represent content for learners.

TPACK extended Shulman's (1986) work on PCK by adding teachers' knowledge of technology to the framework. Although some researchers have asserted that knowledge of technology for teaching is implicitly included in Shulman's (1986) PCK framework (Brantley-Dias & Ertmer, 2013), Koehler and Mishra (2009) argue that the integration of emergent, ever-changing digital technologies into teaching represents a unique challenge to teachers, thereby justifying the addition of technological knowledge as a separate factor in the TPACK framework. According to Koehler and Mishra (2009) digital technologies are *protean* (in that they can be used in a variety of ways and for multiple purposes), *unstable* (in that they are constantly evolving), and *opaque* (in that their "inner workings are hidden from users"; p. 61).

The inclusion of technological knowledge in TPACK created a substantially more complex framework than Shulman's (1986) PCK (Brantley-Dias & Ertmer, 2013). While the PCK framework had only three factors, the TPACK framework has seven discrete factors: (1) Technological knowledge (TK): knowledge that allows individuals to use rapidly changing digital technologies to efficiently and effectively accomplish a variety of tasks, and/or solve problems, (2) Pedagogical knowledge (PK): general knowledge of effective teaching practices, (3) Content Knowledge (CK): subject matter expertise, (4) Technological Pedagogical Knowledge (TPK): knowledge of how technologies can be used to impact teaching and learning, (5) Technological Content Knowledge (TCK): knowledge of the relationship between subject area content and technology, (6) Pedagogical Content Knowledge: knowledge of effective teaching practices for a given subject area, and (7) Technological, Pedagogical Content Knowledge (TPCK): deep knowledge of the relationships between technology, content and pedagogy that enables the implementation of effective technology integration practices (Koehler & Mishra, 2009). A common visual representation of the TPACK framework is included below (Figure 2).

Figure 2
TPACK Visual Representation



In the following section of the literature review, I attempt to provide an overview of some significant themes emerging from the literature on TPACK published in the past decade. This review of the TPACK literature is segmented into four different sub-sections representing major themes emerging from analysis of the included literature. The themes investigated in this review are (a) TPACK measurement, (b) TPACK and teacher level variables, (c) TPACK and student outcomes, and (d) TPACK research in SpecEd.

TPACK Measurement

The majority of studies contained in this review sought to measure and/or describe the TPACK of participants, either through the use of a validated instrument (generally a survey and/or lesson plan or observation rubric), or through qualitative analysis of lesson plans, teacher reflections, transcribed interviews, or other data source. The general assumption that most often lies behind the measurement of teachers' TPACK is that higher TPACK is associated with more effective technology integration practices (Saubern et al., 2020). Nearly 50 TPACK studies were located which created, adapted, utilized and/or validated quantifiable TPACK measurement instruments for use in a variety of content areas, diverse languages and diverse cultural settings, and other research and educational contexts (Acikgul & Aslaner, 2019; Ahlam-Mohammed, 2019; Akman & Guven, 2015; Akturk & Saka-Ozturk, 2019; Ay et al., 2015; Baran et al., 2019; Bingimlas, 2018; Bostancioglu & Handley, 2018; Bozkurt, 2014; Cahyani & Evans, 2021; Chai et al., 2011; Chen & Jang., 2013; Cheung & Jang, 2020; Demirok & Baglama, 2018; Dincer, 2018; Dong et al., 2020; Ersoy et al., 2016; Farrel & Hamed, 2017; Gokdas & Torun, 2017; Graham et al., 2009; Harris et al., 2010; Sahin, 2011; Hsu & Chen, 2018; Horzum et al., 2014; Kadioglu-Akbulut et al., 2020; Kartal & Afacan, 2016; Kihoza et al., 2016; Koh & Chai, 2014; Koh et al., 2014a; Ku et al., 2021; Kumar & Gangmei, 2018; Kurban, 2020; Lee & Tsai, 2010; Martin, 2018; Mtebe & Raphael, 2018; Ramakrishnan et al., 2020; Saltan, 2017; Seyit et al., 2018; Timur & Tasar, 2011; Valtonen et al. 2015, 2017, 2019; Yeh et al., 2013, 2015; Yerdelen-Damar et al., 2017; Yulisman et al., 2019; Yurdakul et al., 2012; Zhou et al., 2017). However, one TPACK survey instrument developed by Schmidt et al. (2009) was found to be the most widely used TPACK measure for research purposes, especially in research contexts related to K-12 education in the United States.

The SPTKTT

The *Survey of Preservice Teachers' Knowledge of Teaching and Technology* (SPTKTT; Schmidt et al., 2009) was initially developed and validated with 124 pre-service teachers (PSTs) in an educational technology course at a U.S university, and in consultation with several TPACK experts. It is a 5-point Likert scale with 47 items that was originally found to measure 10 factors: TK, Math CK, Social Studies CK, Science CK, Literacy CK, PK, TCK, TPK, PCK, and TPCK.

Several studies have offered additional support for the validity and reliability of the SPTKTT. For example, Kaya and DaĞ (2013) confirmed the original 10 factor structure of a Turkish translation of the SPTKTT, which they validated with 362 elementary PSTs.

Other studies have found evidence of convergent validity. For example, Hofer and Grandgenett (2012) found a high level of consistency between results obtained using the SPTKTT, TIAR lesson plan rubric (Harris et al., 2010), and additional qualitative analysis of eight graduate PSTs' written reflections on technology integration. In another study, Huang et al. (2021) found support with both the SPTKTT and the TIAR (Harris et al., 2010) for the categorization of PSTs into two discrete groups, based on their self-regulated learning (SRL) metacognitive profiles.

A number of studies have used the SPTKTT to measure changes in teachers' self-reported TPACK through the comparison of survey results obtained before and after an instructional intervention, demonstrating the instrument's instructional sensitivity. For example, Hofer and Grandgenett (2012) used results obtained with the SPTKTT to demonstrate that graduate level PSTs enrolled in an educational technology course had significantly improved their self-reported TPACK over an academic year. In similar fashion, Xie et al. (2017) used results from the SPTKTT to demonstrate that 109 U.S ISTs' self-reported TPACK had improved during a yearlong digital content evaluation PD program consisting of in-person workshops, online learning modules, and monthly digital content evaluation assignments. Çalik et al. (2014) administered a survey measuring PSTs' perceptions of environmental chemistry related issues, the Chemistry Attitudes and Experience Questionnaire (CAEQ), and a Turkish translation of the SPTKTT to 114 final year secondary science PSTs, both before and after the completion of an environmental chemistry course aligned with the Technology-Embedded Scientific Inquiry (TESI) framework. The researchers found that PSTs' post-course test scores had improved on all three assessment instruments (Çalik et al., 2014).

In another study, Ke and Hsu (2015) used results obtained with the SPTKTT to demonstrate that 34 U.S PSTs had significantly improved their self-reported TPACK after participating in an instructional intervention featuring the creation of mobile augmented reality (AR) artifacts. Notably, significant differences between treatment and control groups' SPTKTT scores were found in this study.

Tournaki and Lyublinskaya (2014) used results from the SPTKTT to demonstrate that SpecEd PSTs improved their self-reported math and science related TCK, TPK, TPACK, and PCK after completing a technology integration course at a U.S university. Additionally, it was found that SpecEd PSTs' self-reported TPACK was comparable to scores previously obtained by administering the SPTKTT to general education PSTs.

Hall et al. (2020) investigated the impacts of a technology integration course designed using Merrill's First Principles of Instruction (FPI) on the self-reported TPACK of 32 early childhood and elementary PSTs at a U.S university. In this study, results obtained with the SPTKTT (Schmidt et al., 2009) and TIAR lesson plan rubric (Harris et al, 2010) both showed that PSTs had significantly improved their TPACK after course completion. However, a larger effect size was found with results from the TIAR.

The SPTKTT has been used in a number of studies that looked for correlations between TPACK and other variables. For example, Kazu and Erten (2014) used a Turkish adaptation of the SPTKTT to investigate the relationship between teacher and school level variables (e.g., demographics, self-efficacy, access to internet), and the TPACK of 280 ISTs working at 15 Turkish primary schools. Another example comes from Lu and Wang (2021), who used a Chinese translation of the SPTKTT to investigate the relationship between the TPACK and technology use experiences of 162 PSTs at four Chinese universities. Lu and Wang (2021) found that PSTs who reported being in environments conducive to technology use (e.g., having access to a technology support network) reported higher TK, CK, TPK, and PCK.

Other studies have used results obtained with the SPTKTT to simply describe the TPACK of a given sample of teachers (as opposed to investigating the impacts of an intervention, or possible correlations with other variables). For example, Mouza and Karchmer-Klein (2013) used results of the SPTKTT to characterize the TPACK of 58 undergraduate PSTs enrolled in a technology integration course at a U.S university. These results served as a point of departure for a larger mixed methods study exploring the PSTs' applied TPACK as they participated in case development-based learning across three consecutive semesters. In another study, Jordan (2013) used a simple descriptive survey design with an adapted version of the SPTKTT to explore the TPACK of 206 first year ISTs in Australia. One interesting finding of this study was that first year ISTs rated themselves lower in technology related TPACK domains (TK, TCK, TPK, TPACK) than other domains (PK, CK, PCK; Jordan, 2013).

The SPTKTT has been adapted by a number of researchers for use in varied contexts. For example, Scrabis-Fletcher et al. (2016) adapted the SPTKTT for use with physical education PSTs in the U.S. Several other studies have adapted versions of the SPTKTT to specifically measure math teachers' TPACK. For example, Zelkowski et al. (2013) validated an adapted version of the SPTKTT for use with secondary math PSTs in the U.S. The survey was found to be valid and reliable, but measured only the basic TPACK factors of TK, CK, and PK. Hill and Uribe-Florez (2019) subsequently used Zelkowski's (2013) adaption of the SPTKTT in a mixed methods design to explore the TPACK and technology integration practices of 28 middle and high school math and SpecEd ISTs in the U.S. Ozudogru and Ozudogru (2019) validated a TPACK survey adapted from the SPTKTT and several other existing instruments with 202 math ISTs in

Turkey. This survey was found to measure six factors: TK, PK, CK, TCK, PCK, and TPACK. Finally, Honey (2018) developed a TPACK instrument adapted from the SPTKTT and various other sources in order to analyze the applied TPACK of 12 primary math PSTs at a U.K university.

Researchers have adapted and/or translated the SPTKTT into different languages for use with PSTs and ISTs in various countries and cultural contexts. For example, Scherer et al. (2017) adapted the SPTKTT to create a survey measuring only the technology-related TPACK dimensions, or “T-dimensions' ' (TK, TPK, TCK, and TPCK), of PSTs in Dutch speaking Belgium. This survey was found only partially valid, as correlations among the T-dimensions were high. In another study, Tondeur et al. (2020) also adapted the SPTKTT for use with Dutch speaking PSTs in Belgium.

Piret et al. (2018) validated a TPACK survey instrument adapted from the SPTKTT and several other sources with 413 PSTs enrolled in an instructional design course at a university in Estonia. In another study, Lehiste (2015) adapted the SPTKTT to include items measuring Estonian ISTs’ TPACK related to the teaching of creative arts.

Young Ju et al. (2018) developed a survey with items adapted from the SPTKTT for use with PSTs in South Korea, while Messina and Tabone (2015) created a 9-item Italian language adaption of the SPTKTT, which included questions about PSTs’ perceptions regarding their teacher educators’ modeling and use of instructional technologies.

Habibi et al. (2020) validated a survey instrument adapted from the SPTKTT and other existing sources with 287 PSTs from three universities in Indonesia. The survey measured the seven standard TPACK factors as well as PSTs' use of information and communication technologies (UICT).

Although the SPTKTT has been widely used by educational technology researchers since its inception, some researchers have raised concerns about the instrument. For example, Shinas et al. (2013) was not able to confirm Schmidt et al.'s (2009) original factor structure. Specifically, the researchers found that TCK was not a discrete and measurable factor. Additionally, PSTs in this study were not able to discriminate between PK and PCK, and one survey item did not load onto any factor. According to Shinas et al. (2013) the SPTKTT may benefit from revisions based on an updated understanding of the TPACK components. Shinas et al. (2013) also suggest that better definitions should be formulated for each TPACK factor.

Khine et al. (2017) validated an Arabic adaption of the SPTKTT with third year undergraduate PSTs at a university in the United Arab Emirates (U.A.E). Although the survey was found reliable for use in Arabic contexts, TCK was not found to be a measurable factor. In another study, Dobi-Barišić et al. (2019) validated the SPTKTT for use in Croatia with 337 early learning and primary school PSTs. All items and subscales of the SPTKTT were found to have good reliability. However, multiple survey items were found to measure both TPK and PCK, suggesting possible flaws in the instrument's structure (Dobi-Barišić et al., 2019).

Some studies have highlighted concerns related to the SPTKTT's reliance on teachers' self-reports. Akyuz (2018) compared a Turkish translation of the SPTKTT with a context specific TPACK performance assessment developed and validated in the same study. Both instruments were administered to 138 PSTs in an elective course on the use of “dynamic geometry software” (DGS) at a Turkish university. Akyuz (2018) found that the performance based TPACK scores were significantly lower than the SPTKTT scores, with the exception of the TCK factor. Despite this concerning finding, an overall significant correlation was observed between scores obtained with the performance assessment and SPTKTT (Akyuz, 2018).

In another study, Harvey and Caro (2017) investigated the impacts of a technology integration course on the self-reported TPACK of 10 undergraduate PSTs at a U.S university. Half of the PSTs were explicitly taught the TPACK framework, while the other half served as a control group. TPACK was measured using both the SPTKTT and an existing lesson plan rubric. PSTs in both groups were found to have improved their SPTKTT scores after completing the university course. However, none of the treatment group members were found to demonstrate any significant applications of TPACK in their lesson plans, demonstrating disparities seen between results obtained with self-report measures (like the SPTKTT) and performance based TPACK measures.

Alawadh et al. (2019) used the SPTKTT in a mixed methods study to analyze the technology integration practices and TPACK of 81 third year undergraduate SpecEd PSTs in Kuwait. While results obtained with the SPTKTT found that PSTs had high levels of overall TPACK, qualitative data analysis indicated that PSTs possessed only moderate levels of TPACK, sometimes lacking the skills needed for effective technology integration (Alawadh et al., 2019).

Baier and Hunter (2020) compared results obtained using the SPTKTT with those of a TPK knowledge test developed and validated for the purpose of investigating the impacts of an instructional technology course on the TPK of 255 PSTs at a German university. The researchers found that TK as measured by the SPTKTT was significantly and positively correlated with results obtained using the TPK knowledge test. However, PSTs' TPK as measured by the SPTKTT was found to have only a small but non-significant correlation with the TPK test results, and PK as measured by the SPTKTT was not found to be correlated with the results of the TPK test at all (Baier & Hunter, 2020).

Kopcha et al. (2014) compared the results of the SPTKTT with results of the TIAR TPACK rubric (Harris et al., 2010) administered to 27 elementary PSTs enrolled in an undergraduate technology integration course at a Midwest U.S university. In this study, the SPTKTT and TIAR scores were not found to be significantly correlated as a whole, nor among individual TPACK factors. Qualitative findings from this study suggest the TIAR may provide more reliable TPACK measurements than the SPTKTT. According to Kopcha et al. (2014), the SPTKTT survey might capture teachers' self-confidence regarding TPACK rather than genuine knowledge that can be applied in practice.

Wen and Shinas (2021) used a multiple case study design to investigate the impacts of a course focused on technology integration and the integration of literacy instruction on the TPACK of 26 graduate level PSTs at a U.S university. Data obtained with both the SPTKTT, and a TPACK lesson plan rubric showed that PSTs who completed the university course made significant improvements in all TPACK components, with the exception of PK. Although this study provided some evidence of convergent validity for the SPTKTT, the lesson plan rubric was found to be more sensitive to subtle differences in PSTs' TPACK. According to Wen and Shinas (2021), their findings suggest that researchers should consider using multiple measures to better capture the nuances of teachers' TPACK.

Schmid et al. (2021) used a TPACK measure adapted from the SPTKTT to investigate the relationship between the self-reported TPACK and evidence of planning for instructional technology use of 173 graduate level PSTs at a Swiss University. Schmid et al's (2021) survey was found to measure the seven standard TPACK factors. In this study, PSTs' planning for technology use was not found to be significantly correlated with overall self-reported TPACK. However, it should be noted that Schmid et al. (2021) used only a single lesson plan that PSTs created for a fictional context as evidence of their planning for technology use. Schmid et al. (2021) suggest that a *Dunning-Kruger* effect (where novices are likely to overestimate their knowledge or abilities in a given domain) may impact the results of self-report TPACK measures like the SPTKTT. Nonetheless, Schmid et al. (2021) argue that TPACK self-report surveys such as theirs are still useful for researchers, especially when combined with other methods for evaluating and exploring teacher TPACK.

The SPTKTT has been used extensively in the TPACK research of the past decade. It has been administered or adapted by international researchers in varied contexts to measure the self-reported TPACK of both PSTs and ISTs. Although several studies have provided good evidence for the SPTKTT's reliability, convergent validity, and instructional sensitivity, its validity and reliability have also been questioned due to its reliance on teachers' self-reports. Additionally, several studies have found inconsistencies in the factor structure of the instrument. In particular, several researchers have noted specific problems related to the measurement of the intermediate TPACK factors (Baier & Hunter, 2020; Khine et al., 2017; Shinas et al., 2013). In light of these concerns, it seems prudent to follow the recommendations of Wen and Shinas (2021): when possible, researchers who utilize the SPTKTT should combine it with one or more performance based TPACK measures, and/or a qualitative analysis of teachers' TPACK. Despite its limitations, the SPTKTT is widely considered to be a "valid and efficient tool for research…relating to TPACK" (Abbit, 2011, p. 291). Furthermore, although the SPTKTT was developed more than a decade ago, it continues to be used and adapted by researchers seeking to measure teacher TPACK via survey administration.

Qualitative Evaluations and Descriptions of TPACK

A number of studies were found which mainly evaluated teachers' TPACK through the analysis of qualitative data, rather than with a formalized and validated TPACK measurement instrument. The studies below generally used data derived from teachers' lesson plans, conversations between teachers and students, teacher reflections, and interviews. Interestingly, ISTs were found to be overrepresented as participants in studies that used qualitative methods to evaluate TPACK; while approximately 37% of studies analyzed in this review explored the TPACK of ISTs using a validated TPACK instrument, 50% of studies that used qualitative methods to evaluate teachers' TPACK featured ISTs as participants. Many of these studies provided rich, detailed descriptions of teachers' actual technology integration practices, or what might be referred to as their "applied TPACK".

Several included studies used qualitative methods to evaluate teachers' TPACK in content (subject area) specific contexts. For example, Cheung and Jang (2020) used content analysis and qualitative coding of transcribed classroom conversations and teaching observation field notes to evaluate the writing instruction related TPACK of five 4th grade ISTs in Singapore.

Hill and Uribe-Florez (2019) used a mixed methods design to explore the applied TPACK of 28 middle and high school math ISTs (including SpecEd ISTs working in math classrooms) employed in a rural U.S school district. Qualitative data were obtained using open-ended questions on technology integration created by the researchers. The ISTs in this study reported using technological tools to create visual representations and virtual manipulatives used to build students' conceptual understanding of math content. The ISTs also reported that technology allowed them to differentiate instruction, to increase their own work efficiency, and to provide students with personalized learning opportunities. Additionally, ISTs reported that technology allowed students to be more independent in their learning and to explore authentic real-world topics. Most ISTs believed they engaged in effective technology integration practice and/or wanted to improve their skills in this area. ISTs identified several obstacles to technology integration, including insufficient access to technological resources, and a lack of time for planning with and/or learning about technology. Overall, the findings of this study support the notion that ISTs' TPACK can be observed in their technology integration practices (Hill & Uribe-Florez, 2019).

Maeng et al. (2013) used a qualitative case study design to explore the applied TPACK of 26 science PSTs enrolled in a graduate level instructional technology course at a U.S university. Data were obtained through interviews with PSTs, teaching observations, and teaching artifacts (e.g., lesson plans). The researchers reported qualitative evidence for PSTs' developing TPACK in lessons and teaching, as they were found to use technology intentionally, remaining sensitive to the context and purpose of technology integration.

Harris and Hofer (2011) used a qualitative interpretivist design to investigate the impacts of a TPACK related PD offering on the applied TPACK of seven experienced social studies ISTs. Qualitative data consisted of interviews with ISTs, lesson plans, and teacher reflections, which were coded for evidence of ISTs' TPACK. In this study, it was found that ISTs were more discriminating and strategic in their use of technology based instructional activities and resources and used a wider variety of resources after engaging in the PD offering. ISTs were also found to engage in more student-centered lesson planning, and to utilize technology to spark intellectual curiosity rather than emotional or affective interest in their students after participating in the PD.

In another study, Pringle et al. (2015) investigated the impacts of a yearlong statewide technology integration training initiative on the applied TPACK of more than 200 science ISTs in the U.S. Qualitative data consisted of ISTs' lesson plans which were collected before and after the training initiative and were coded for evidence of TPACK. In this study, it was found that ISTs demonstrated improved TK through the increased use of sophisticated technologies like digital microscopes, and decreased use of digital spreadsheets. Evidence of improved PK was found in ISTs' increasing use of constructivist teaching practices, and performance-based assessments. Some evidence for improved TPK was found in a small percentage of lessons which planned for students' autonomous use of technology, and in ISTs' increasing use of technological tools which featured as "integral components in the development of lesson plans" (Pringle et al., 2015, p.659). It was also found that ISTs' lesson plans (both before and after the intervention) frequently included activities with low cognitive demand and had an insufficient number of tasks with high cognitive demand (suggesting possible deficits in ISTs' PCK). Additionally, both before and after the intervention, ISTs' lessons infrequently incorporated science-specific software tools, suggesting TCK may not have been significantly impacted by the intervention (Pringle et al., 2015).

Several included studies used qualitative methods to evaluate the teachers' applied TPACK in technology specific contexts. For example, Honey (2018) used a naturalistic interpretivist design study to analyze the applied TPACK of 12 primary PSTs at a U.K university. Qualitative data were obtained through PSTs' completed lesson plans, and via observations of PSTs working on a collaborative graphing calculator-related lesson planning and implementation activity. The data were then coded for evidence of PSTs' TPACK. In this study, qualitative data were used alongside quantitative data obtained through an adapted TPACK instrument in order to develop a well-rounded understanding of the math PSTs' applied TPACK. Honey (2018) found that high levels of TK, CK, and PK may not be sufficient for good technology integration practice; teachers' beliefs about technology also may play a critical role.

In another study, Tseng (2018) used a mixed methods design to explore the applied TPACK of secondary Taiwanese English as a Foreign Language (EFL) ISTs' who used a supplemental online program called "Cool English" to enhance their standard curriculum. Qualitative data consisted of ISTs' lesson plans, teaching observations, and interviews with ISTs. A priori codes developed in accordance with the TPACK-SLA (Second Language Acquisition) framework were used for qualitative data analysis.

Tokmak et al. (2013) used a qualitative case study to explore the applied TPACK of 21 early childhood PSTs enrolled in a Turkish university education course that involved the development of original educational computer games, which were subsequently used for instruction. Qualitative data included transcribed focus group interviews, PSTs' journal entries, and educational computer games created by the PSTs. The data were coded for evidence of PSTs' TPACK and design knowledge (DK). The researchers found that the design of educational computer games was found to promote the development of the PSTs TPACK and DK.

Blau et al. (2016) explored the applied TPACK of 15 seventh grade ISTs in Israel working at schools in which each student was given their own laptop. Data were collected through teaching observations, and interviews with ISTs using a TPACK based protocol developed and validated by the researchers. Qualitative content analysis was then used in the coding of data for evidence of TPACK factors. ISTs in this study were found to predominantly utilize teacher-centered instructional methods and traditional (non-digital) materials despite the availability of 21st century technologies, providing evidence of specific TPACK related deficits.

Blonder and Rap (2017) used a qualitative case study design to explore the applied TPACK of three high school ISTs who used Facebook groups to teach chemistry. Qualitative data consisted of communications and interactions between ISTs and their students on Facebook learning group pages over the course of two school years. In this study, it was found that the use of the Facebook learning groups allowed ISTs to develop chemistry related TPACK.

Eutsler (2020) used a qualitative case study design to investigate the impact of five workshops related to iPad integration on the TPACK development of 38 elementary PSTs enrolled in a literacy methods course at a U.S university. Qualitative data for this study consisted of teaching observation logs and PSTs' lesson plans. According to Eutsler (2020), the findings of this study suggest that teacher preparation programs can use the gradual release of responsibility framework to help PSTs develop their TPACK. Minicozzi (2018) also explored TPACK in relation to PSTs' iPad integration using a qualitative case study design. In this study, qualitative data were obtained through TPACK aligned focus group interviews, surveys, and PSTs' lesson plans and reflections.

A number of included studies used qualitative methods to evaluate the impacts of a university course, or other instructional intervention (e.g., PD) on educators' TPACK. For example, Tokmak et al. (2013) used a qualitative action research design to investigate the impacts of a TPACK based instructional design course on the instructional material design (IMD) related knowledge and skills of 22 second-year elementary PSTs enrolled in a night-school teacher preparation program. Qualitative data included PSTs' journal entries, and researchers' observation notes, which were first coded, and then analyzed for emergent themes. In this study, PSTs were found to have improved their IMD related TPACK after completing the instructional design course.

Koh and Chai (2016) used qualitative methods to explore the applied TPACK of 27 primary ISTs in Singapore as they designed, developed and implemented lesson plans featuring technology integration in subject and grade level specific collaborative teams across a single school year. All ISTs attended an eight-hour PD session which introduced them to 21st century skills, and Howland et al.'s (2013) five dimensions of meaningful learning. Thematic data analysis with chi-square corroboration was used to determine the "design frames" teachers used in developing lessons in collaborative teams. Data were obtained through recordings of collaborative lesson planning sessions, and discussions between the researchers and ISTs. The data were coded for evidence of TPACK, with design knowledge (DK) added to the seven standard TPACK factors. The findings of this study suggest that PCK and TPACK may be the most important TPACK factors contributing to ISTs' technology integration and related instructional design practices. According to the researchers, good collaboration between ISTs was essential for quality design work, and ISTs' DK may be a critical factor impacting their overall TPACK. Koh et al. (2014b) reported similar findings, noting that ISTs must intentionally engage in pedagogical discussions to improve TPACK co-construction during lesson planning.

Holmberg et al. (2018) used qualitative methods to explore the impact of participation in a longitudinal design-based research (DBR) project on the applied TPACK of eight upper secondary EFL ISTs in Sweden. In this study, the ISTs were found lacking in the practical and specific TK required to independently enact ideas in practice, but their general and theoretical TK helped them build the knowledge and skills necessary for eventual implementation. The researchers concluded that participation in DBR may positively impact ISTs applied TPACK (Holmberg et al., 2018).

Koh et al. (2014b) used qualitative methods to evaluate the TPACK of 24 primary ISTs at FutureSchools in Singapore, which is a school focused on pervasive technology integration. ISTs participated in teacher-leader facilitated PD in grade level groups which met during the semester to discuss lessons and curriculum.

Hutchison and Colwell (2016) used qualitative methods to explore the applied TPACK of 48 PSTs in an intermediate literacy methods class at a U.S university, which explicitly taught and guided students through the use of the Technology Integration Planning Cycle (TIPC). The researchers found that PSTs' use of the TIPC helped them improve their TPACK and technology integration skills (Hutchison & Colwell, 2016).

Mouza (2011) used a qualitative case study design to investigate the impacts of a technology integration related PD program on the TPACK of eight ISTs working in U.S charter schools. Qualitative data consisted of case narratives, teaching artifacts, teaching observations, and open-ended questions. In this study, it was found that prior to the PD, ISTs reported high levels of comfort with technology but relatively low levels of instructional technology use. Overall, it was found that ISTs' technology integration practices were often teacher centered. According to the author, case development activities in the PD may have helped ISTs engage in critical reflection on their teaching practice, leading to improved TK, TPACK, and technology integration. However, most ISTs were found to have beginning levels of TPACK even after the PD (Mouza, 2011).

Three studies used qualitative methods to evaluate and describe the TPACK that PSTs bring with them to teacher education programs. In one such study, Kontkanen et al. (2014) examined the TK, PK, and TPK of 141 first year PSTs at a university in Finland using qualitative data obtained with open ended response items. In this study, PSTs' PK and TPK were found to be at early stages of development. PSTs were also found mainly to describe teacher-centered pedagogical practices and uses of technology, while only a minority mentioned student-centered approaches. The findings of this study suggest that PSTs bring with them "proto-TPACK" (based on prior experiences with technology, including the use of technology for entertainment as well as for learning) which must be developed during their teacher preparation programs (Kontkanen et al., 2014). In a second study, Kontkanen et al. (2016) found limited proto-TPACK among a group of 84 3rd year Finnish upper secondary PSTs who had been integrating iPads during their studies. In a third study, Valtonen et al. (2020) used qualitative data analysis of Finnish PSTs' lesson plans and reflections in order to better define PSTs' proto-TPACK, as well as their specific challenges and strengths related to technology integration. According to Valtonen et al. (2020), PK is the TPACK domain PSTs are most aware of and concerned about. In fact, Valtonen et al. (2020) write that "PK is the *core* of developing TPACK" (p. 2840). For this reason, they argue that strategies aimed at improving PSTs' PK could function as starting points for teacher preparation programs seeking to develop PSTs' overall TPACK (Valtonen et al., 2020).

Several included studies used qualitative methods to explore educators' applied TPACK in SpecEd contexts. For example, Courduff et al. (2016) used open, axial, and selective coding to analyze data obtained from interviews with, and teaching observations of, 10 SpecEd ISTs in the U.S. In another study, Oakley et al. (2013) used qualitative data analysis of lesson plans and field placement teaching observations to evaluate the TPACK of two Australian SpecEd PSTs.

Anderson and Putnam (2020) used thematic qualitative data analysis of eight SpecEd ISTs' interviews and teaching observations to investigate their experiences, confidence, knowledge and beliefs about technology integration. Qualitative coding was used to find evidence of ISTs' applied TPACK. The majority of coded findings in this study related to TK or TPK (less related to TCK and TPACK).

Anderson et al. (2017) used qualitative data analysis to explore and describe the applied TPACK of 14 early childhood SpecEd PSTs at a private university in the U.S. The PSTs taught lessons to one or two students with mild disabilities (ages 6-11) while simultaneously working on a project aimed at building PST skills related to iPad and general technology integration. Qualitative data consisted of transcribed focus group interviews with PSTs, and individual interviews with 11 SWDs. Additionally, PSTs' lesson plans and reflective journals were used as secondary data sources.

Correlations Between TPACK and Other Teacher Level Variables

A number of studies sought to determine if correlations existed between teachers' TPACK and other teacher level variables (e.g., demographics). Four main teacher level variables emerged from the included literature: (a) teacher gender, (b) teacher age, (c) teaching experience, and (d) teacher self-efficacy. It should be noted that while some researchers argue that teachers' TPACK self-reports could actually be considered measures of teachers' self-efficacy (Kopcha et al., 2014), several of the studies included in this section treated self-efficacy (related to technology integration) and TPACK as separate constructs to be measured independently.

TPACK and Gender

Eight studies included in the current review found that male educators reported higher levels of TPACK in technology related domains (TK, TPK, TCK, TPACK). For example, Jordan (2013) found that male ISTs rated themselves higher in the majority of intermediate TPACK domains (especially TPK and TCK), and TPACK overall. Multiple researchers found that male PSTs rated themselves higher than female PSTs on TK (Piret et al., 2018; Chen & Jang., 2013; Ozudogru & Ozudogru, 2019). Lu and Wang (2021) found that male PSTs rated themselves significantly higher in TK and TPK than female PSTs. Koh et al. (2014a) found that male ISTs scored themselves higher than female ISTs on constructivist-oriented TK and TPACK, although the effect size was small. Both Kartal and Afacan (2016), and Scherer et al. (2017), found that male PSTs reported higher scores than female PSTs on technology related TPACK domains. Scrabis-Fletcher et al. (2016) found that male physical education PSTs reported higher TCK than female physical education PSTs.

Three included studies found that male educators rated themselves significantly higher than female educators in non-technology related TPACK domains. For example, Lu and Wang (2021) found that male PSTs self-reported higher levels of PCK than female PSTs. Piret et al. (2018) found that male PSTs rated themselves higher than female PSTs in CK, and PK. Koh et al. (2014a) found that male ISTs scored themselves higher than female ISTs in constructivist-oriented CK.

Five included studies found that female educators rated themselves higher in non-technology related TPACK domains than their male counterparts. Multiple researchers found that female ISTs rated themselves higher in PK (Hsu & Chen, 2018; Jordan, 2013; Kazu & Erten, 2014). Farrell and Hamed (2017) found that female ISTs had higher self-reported CK and PCK than males.

Three included studies found that female educators rated themselves higher than males ISTs or PSTs in technology related TPACK domains. Cahyani and Evans (2021) found that female SpecEd ISTs scored higher than male SpecEd ISTs in TK and TPACK. Kazu and Erten (2014) found that female ISTs reported significantly higher TPK than male ISTs. Ahlam- Mohammed (2019) found that female PSTs self-reported higher

TPACK confidence related to their "readiness to engage in ICT practices to transform student learning outcomes" (p. 3410).

Six studies included in the current review found no significant differences between female and male educators' assessed levels of TPACK (Akturk & Saka-Ozturk, 2019; Demirok & Baglama, 2018; Ersoy et al., 2016; Kumar & Gangmei, 2018; Martin, 2018; Saltan, 2017).

The included literature provides some support for the assertion that, on average, male teachers may rate themselves higher in technology related TPACK domains, while female teachers may rate themselves higher in non-technology related TPACK domains. However, the underlying causes of these apparent gender-based differences were not explained satisfactorily by any of the reviewed literature. Furthermore, contrary evidence was found for both of the above assertions. It must be stressed that the overwhelming majority of studies providing evidence for gender-based differences in TPACK relied on data obtained from teacher self-reports. Future research could shed additional light on this topic by comparing the TPACK of male and female educators using more objective TPACK assessments, such as performance-based measures (e.g., lesson plan rubrics and/or teaching observations).

TPACK and Teacher Age

Three studies reported findings suggesting that on average, younger educators may report higher levels of technology related TPACK than older educators. In one study, Piret et al. (2018) found a significant negative correlation between graduate level PSTs' age and TK. In another study, Koh et al. (2014a) also found small negative correlations between ISTs' age and technology related constructivist-oriented TPACK domains (i.e., C-TK, C-TPK, TCK, C-TPACK). Finally, Kazu and Erten (2014) found that increased IST age was associated with decreased self-reported TK.

These same three studies also reported findings suggesting that older educators may report higher levels of some non-technology related TPACK domains. For example, Kazu and Erten (2014) found that older ISTs reported higher levels of PCK, and Koh et al. (2014a) found small but significant positive correlations between ISTs' age and self-reported constructivist oriented PCK. Additionally, Piret et al. (2018) found a significant positive correlation between graduate level PSTs' age and CK.

Three included studies provided evidence countering the above assertions related to educator age and TPACK. Two studies investigated this relationship and found no significant correlations between ISTs' age and self-reported TPACK (Demirok & Baglama, 2018; Hsu & Chen, 2018). Furthermore, Dong et al. (2015) found that ISTs with a mean age of 36.06 reported higher TK than PSTs with a mean age of 20.59. This finding is particularly interesting as it stands in direct contrast to the research suggesting younger teachers may have higher levels of TK.

TPACK and Teaching Experience

Six included studies reported findings suggesting that ISTs' teaching experience may be negatively correlated with one or more technology related dimensions of their TPACK. For example, Kazu and Erten (2014) found ISTs with more teaching experience reported lower levels of TK. Demirok and Baglama (2018) found a negative correlation between ISTs' teaching experience and TPACK levels. Farrell and Hamed (2017) found that ISTs' teaching experience was significantly and negatively correlated with TK, PK, TPK, TCK, and TPACK. Koh et al. (2014a) found that ISTs with more experience rated themselves lower in the technology related domains of constructivist oriented TPACK. The authors suggest this finding might be due ISTs with more experience becoming more established in fixed routines, meaning they may lack the flexibility needed to implement new and creative pedagogies with the use of technology in their classrooms (Farrell & Hamed, 2017). Akturk and Saka-Ozturk (2019) found that ISTs with less professional experience (0-10 years) reported higher TPACK scores, on average, than ISTs with more professional experience. Additionally, it was found that ISTs with 11-20 years of experience reported higher average TPACK scores than ISTs with 21 or more years of experience (Akturk & Saka-Ozturk, 2019). Xie et al. (2017) found that ISTs with less experience saw greater gains in TPACK after participating in a digital content evaluation PD program. The researchers hypothesize that less experienced teachers may have had "transformational" experiences with regard to technology integration during the PD, whereas more experienced teachers may have seen more "incremental" change. It is possible that ISTs with greater experience had already been exposed to some of the ideas presented in the PD, whereas these ideas were new, and thus more impactful, for ISTs with less experience.

Three included studies found that greater teaching experience was associated with increased levels of ISTs' TPACK in one or more dimensions. For example, Chen & Jang (2013) found a positive correlation between ISTs' teaching experience and overall TPACK. Hsu and Chen (2018) found that, on average, ISTs with more than nine years of experience had significantly higher self-assessed PK than teachers with 3-5 years of experience. Kazu and Erten (2014) found that greater teaching experience was associated with increases in ISTs' PCK.

Two studies reported finding no evidence of differences in TPACK between educators with differing levels of experience. For example, Ozudogru and Ozudogru (2019) found no significant correlation between the teaching experience and TPACK of math ISTs. Similarly, Martin (2018) found no evidence that teaching experience significantly impacted the technology integration practices of a sample of teacher educators.

In one study, Anderson and Putnam (2020) reported context-specific, qualitative evidence for apparent differences in the applied TPACK of ISTs with differing levels of experience. Data were obtained through in-depth interviews with ISTs. In this study, it was found that more experienced ISTs with low levels of technological confidence made statements related to TK and TCK more than other TPACK areas and were especially concerned about whether technology could support student growth. ISTs with medium levels of experience and high levels of technological confidence made statements related to the use of technology as a pedagogical tool (Anderson & Putnam, 2020).

Overall, the reviewed literature provides some evidence that ISTs' teaching experience may be negatively correlated with technology related TPACK dimensions, and positively correlated with pedagogically related TPACK dimensions. However, the studies that found no significant correlations between teaching experience and ISTs' TPACK offer contrary evidence. It seems reasonable to assume that, on average, teachers' age is significantly correlated with their years of teaching experience. If it is correct that research findings suggesting negative correlations between teachers' age and technology related TPACK may at least partially be measuring the impact of teachers' *generation* (with age as a proxy) on TPACK, then the same phenomena might explain some of the findings related to teaching experience and TPACK. However, it may also be that as ISTs gain more experience, they tend to fall into teaching habits and patterns which are hard to break, and which make them less likely to adopt the use of emerging instructional technologies. Conversely, perhaps ISTs with less experience may be more willing to explore the use of emerging technologies in their teaching, allowing them more opportunities to develop TPACK related to the newest digital tools (Farrell & Hamed, 2017).

TPACK and Self-Efficacy

Three included studies reported findings which suggest that educators' TPACK may be positively correlated with self-efficacy beliefs and related technology integration practices. Self-efficacy can be defined as an individuals' beliefs related to their own capabilities (Bandura, 1977), and may in some cases predict actual teacher behavior (Voogt et al., 2013). For example, Young Ju et al. (2018) found that PSTs' TPACK was positively correlated with their self-efficacy. In another study, Blonder and Rap (2017) found that ISTs' self-efficacy regarding the use of facebook groups for teaching chemistry was an important factor in their applied TPACK. Yerdelen-Damar et al. (2017) found that PSTs' attitudes towards technology use, technological competencies, and experience using technology were positively correlated with their TPACK self-efficacy. The converging findings from these studies all suggest that teachers' self-efficacy related to technology integration may be an important factor shaping their actual applications of TPACK.

<u>TPACK and Student Outcomes</u>

All but one of the included studies which reported findings substantially related to the impact of educators’ TPACK on student outcomes were conducted with IST participants. This is not surprising, given that PSTs are generally not held responsible for the overall learning outcomes of students in their practicum or student teaching placements.

Five included studies reported findings suggesting that ISTs’ TPACK may have a positive impact on student outcomes. For example, Akturk and Saka-Ozturk (2019) used a quantitative survey design with multiple linear regression to investigate the impact of ISTs’ TPACK and student self-efficacy on the academic achievement (GPA) of students in Turkey. It was found that ISTs’ TPACK and students’ academic and social-emotional self-efficacy explained approximately 12% of the variance in students’ GPA. However, students’ academic and social-emotional self-efficacy were found to be more significant predictors of their academic achievement than ISTs’ TPACK. In a qualitative study, Minicozzi (2018) found that three out of eight SpecEd PSTs reported positive impacts on student learning as a result of using an iPad app called “One Minute Read” for literacy instruction. Oakley et al. (2013) used both qualitative and quantitative data to support their assertion that ISTs’ TPACK can be applied to promote the academic achievement and confidence of students with autism spectrum disorder (ASD) in the selection and utilization of instructional content that is of high interest to learners. Cheung and Jang (2020) used a qualitative research design to explore the applied writing related TPACK of five 4th grade ISTs in Singapore. In this study, it was found that ISTs with strong PCK (as opposed to merely strong CK) were able to increase student engagement during lessons. Tseng (2018) used qualitative data to support the finding that EFL ISTs used the "Cool English" online English learning platform to enhance the standard curriculum by (a) using annotated animations to teach grammar, (b) using digital images to teach vocabulary, and (c) facilitating student conversations with chatbots used to analyze sentence patterns. According to Tseng (2018), these ISTs applied TPACK "exerted a discernible impact on student learning" (p. 409). However, it should be noted that evidence for student learning was obtained via qualitative student self-reports.

Two included studies reported findings not supportive of the assertion that ISTs' TPACK positively impacts student learning. In one quantitative study, Havard et al. (2018) investigated the relationship between students' use of calculators and computers for learning, ISTs' participation in PD related to calculator use, and the math achievement of 4th grade students in the U.S. Data for this study consisted of five years' worth of recent 4th grade NAEP mathematics assessment results. The assessment measured 4th grade students' math achievement, as well as their use of computers, use of calculators, and the technology related professional development activities of their teachers. ANOVA testing was used to investigate the relationship between these variables. In this study, the researchers found a significant negative correlation between ISTs' participation in PD related to the use of calculators, and the math achievement of their students. In other words, the 4th grade students of ISTs who had participated in more calculator related PD were found to have lower math achievement scores. It is important to recognize that Havard et al. (2018) did not directly measure or attempt to assess ISTs' TPACK, although TPACK was used as the guiding theoretical framework for this study.

In another quantitative study, Farrell and Hamed (2017) investigated the relationship between ISTs' TPACK and students' academic achievement with 304 ISTs in Broward County, FL. Data on student academic achievement was derived from ISTs' Value-Added Model (VAM) scores, which represent an official measure of teacher effectiveness used by the state of Florida. A survey was used to measure ISTs' TPACK and to collect data on teacher demographics and school related variables. In this study, it was found that ISTs working at schools with a high percentage of economically disadvantaged students had significantly lower VAM scores than ISTs working at schools with lower percentages of economically disadvantaged students. However, no significant correlations were found between ISTs' self-reported TPACK and VAM scores. According to the researchers, these findings imply one or more of three possibilities: (a) Florida's VAM model for measuring teacher effectiveness is flawed (e.g., ISTs' VAM scores may be significantly impacted by their students' socio-economic status, which is not within their direct control), (b) The TPACK survey used in this study (Sahin, 2011) produced biased results which do not accurately reflect teachers' actual TPACK or technology integration practices, and/or (c) ISTs' TPACK does not have a significant impact on the academic achievement of students.

The majority of support for the assertion that teachers' TPACK positively impacts student outcomes (e.g., academic achievement) was found to come from qualitative studies included in the current review. In these studies, student outcomes were largely measured based on teacher and/or student self-reports, or qualitative analysis of data obtained through observations and/or the collection of teaching artifacts. While findings from these studies illuminate possible mechanisms that may allow teachers' TPACK to impact student outcomes, they do not provide hard evidence establishing an actual impact. Only two studies were found to provide quantitative evidence supporting a significant and positive correlation between teachers' TPACK and student outcomes (Oakley et al., 2013), and in one such study, the impact of teachers' TPACK on student academic achievement was found to be relatively small (Akturk & Saka-Ozturk, 2019). Furthermore, the two studies which were found to offer counter evidence for this assertion both used quantitative methods (Farrell & Hamed, 2017; Havard et al., 2018), although as has been shown, the data sources used in these latter studies somewhat limit the validity and reliability of findings. Overall, it appears that the included literature provides insufficient evidence to conclude whether and how teachers' measured TPACK impacts student outcomes, especially academic achievement. More research on this topic is therefore needed. However, for the purposes of this study, it is assumed that higher levels of teacher TPACK are associated with more effective teaching practices, and subsequently, higher levels of student achievement.

TPACK Research in SpecEd

Three included studies explored and/or described the applied TPACK of SpecEd PSTs. All of these studies utilized qualitative or mixed methods designs. For example, Oakley et al. (2013) used a mixed-methods case study design to explore the applied TPACK of two Australian SpecEd PSTs. In their field placements, the PSTs implemented tech-enhanced literacy interventions which were designed with the aid of identified evidence-based instructional practices for students with ASD. Data were obtained through analysis of PSTs' lesson plans, and through teaching observations. Pre and post intervention measures of student academic performance and attitude were also compared.

According to the researchers, the findings of this study support the use of instructional content related to student interests in order to positively impact the academic confidence and achievement of students with ASD (Oakley et al., 2013).

Minicozzi (2018) used qualitative methods to explore the applied TPACK of eight graduate level PSTs enrolled in an early learning and SpecEd dual certification program. The PSTs were also working on iPad integration within a practicum field placement. In this study, it was found that SpecEd PSTs reported receiving little if any instruction related to iPad integration in their teacher preparation program. However, the SpecEd PSTs expressed general confidence related to the use of mobile technologies and reported more comfort with iPad integration after taking a technology related teaching methods course. The SpecEd PSTs were also found to possess background knowledge on instructional differentiation which helped them effectively integrate the iPads into their instruction. All PSTs reported that the iPads were especially beneficial when working with students with learning disabilities. According to Minicozzi (2018), these findings suggest that it is important for teacher preparation programs to give PSTs opportunities to design lessons that feature iPad integration in order to build their TPACK.

Anderson et al. (2017) used qualitative methods to explore the applied TPACK of 14 early childhood SpecEd PSTs at a private university in the U.S, who were introduced to the TPACK framework in a university course. Each PST in this study worked to integrate iPads into instructional activities with 1-2 students with mild disabilities (age 6-11). Data in this study consisted of transcripts of focus group interviews, individual interviews with 11 SWDs, PSTs' lesson plans, and PSTs' reflective journals. In this study, the researchers uncovered two kinds of decisions the SpecEd PSTs made when teaching with technology: (a) planned decisions and (b) in the moment decisions. Anderson et al. (2017) also found that PSTs used two kinds of knowledge when making instructional decisions: (a) decisions based on TPK (general pedagogical strategies), and (b) decisions based on TPACK (taking into account the content being taught).

According to Anderson et al. (2017), the PSTs' selection and utilization of specific apps in lessons was largely informed by their TPACK. Some PSTs were surprised by the time and effort required to plan lessons with iPads. The PSTs also expressed their feeling that there were too many apps to choose from, and that available apps didn't always meet the needs of students, or adequately address learning objectives. However, the majority of PSTs expressed feeling that their efforts to integrate iPads into instruction were worthwhile. Some PSTs were found to use apps to monitor progress (assess content knowledge), and PSTs generally were found to adjust their lessons based on observations of students as they used the apps. PSTs were observed using explicit instructional techniques to review prior learning, offer feedback, and allow for extra guided practice while using the iPads. Behavioral management challenges were also found to be associated with some students' use of iPads. PSTs were found to use these behavioral challenges as opportunities for building students' social skills and applying the knowledge they had acquired related to behavior management. Many PSTs were observed using iPads with students towards the end of a lesson, after finishing less preferred tasks. According to Anderson et al. (2017), the students seemed to enjoy using the iPads, felt they were easy to use, and believed they helped them to learn.

Anderson et al. (2017) use these findings to support their assertion that instructional practices backed by research are fundamental to effective technology integration in SpecEd settings. The researchers note that although we increasingly hear calls for instructional technologies to be used to support constructivist learning practices, “teacher-directed approaches, such as explicit instruction, are appropriate for technology-enhanced learning in SpecEd settings” (p. 99).

Five included studies explored and/or described the applied TPACK of SpecEd ISTs, with three of these studies using quantitative methods, and two using qualitative or mixed methods designs. In one study, Ramakrishnan et al. (2020) used a basic quantitative survey design to explore the TPACK of 229 SpecEd ISTs working at vocational SpecEd secondary schools in Malaysia. Data were collected with a survey to measure ISTs' TPACK, teaching styles, self-efficacy, and competency. In this study, the SpecEd ISTs were found to have high levels of overall TPACK, with the highest component being PCK. ISTs were mainly found to use a “facilitator” teaching style, and were found to have high self-efficacy, especially related to classroom management. ISTs were found to have high levels of competency, especially in relation to their role as an advisor of students. According to the researchers, the TPACK, teaching style, self-efficacy and competence of this sample of SpecEd ISTs contributed to their teaching excellence. In another study, Cahyani and Evans (2021) investigated the TPACK of 44 Indonesian SpecEd ISTs using a basic descriptive survey design. In this study, all SpecEd ISTs were found to self-report “good” or “very good” overall TPACK scores, and TK was found to be the highest factor for all ISTs. In the third quantitative study, Demirok and Baglama (2018) used the TPACK-Deep scale (Yurdakul et al., 2012) to investigate the TPACK of SpecEd ISTs in North Cyprus. In this study, SpecEd ISTs were found to report high levels of overall TPACK. However, the researchers also concluded that SET preparation programs would benefit from additional courses focused on technology integration (Demirok & Baglama, 2018).

Courduff et al. (2016) used a qualitative, systemic grounded theory design to explore and detail the applied TPACK of 10 SpecEd ISTs in the U.S who were identified as having demonstrated exemplary technology integration practices (e.g., by winning an award, or being recommended by a school administrator). Data were obtained through survey administration, interviews with ISTs, and observations. A focus group of experts was also convened prior to data collection to develop a list of criteria for exemplary technology integration practice in SpecEd, which was used to inform subsequent aspects of the study.

Courduff et al. (2016) found that ISTs began adopting technology after being exposed through their PD or teacher preparation programs, or out of “desperation” to improve their teaching practice. It was also found that the ISTs in this study were open-minded and curious about the potential positive impacts technology use could have on student outcomes. The ISTs considered experimentation and risk-taking as essential aspects of effective technology integration. These ISTs were also found to be “lifelong learners” who believed in active and student-centered learning and gave primary consideration to students’ needs and learning objectives when selecting technological tools. Notably, the researchers found no evidence of major transformative experiences related to the development of these SpecEd ISTs’ TPACK. Rather, their TPACK was found to develop gradually through consistent trial and error.

According to Courduff et al. (2016), SpecEd ISTs used technology to create enhanced and differentiated learning activities, to provide students with instructional scaffolding, and to gradually facilitate shifts towards student independence and autonomy. The ISTs were found to provide a structured environment and clear guidelines for students when using technology, emphasizing the importance of student safety when using the internet. The ISTs demonstrated flexibility integrating technology, using technology in ways that were planned, but also improvising to meet student needs in the moment. The ISTs were also found to use systematic methods for evaluating the effectiveness of their technology integration practices, especially with respect to student learning. The ISTs identified student skill deficits, availability of technological tools, IT support, and lack of training as barriers to technology integration, but all participants were found to demonstrate resilience in the face of such barriers. The researchers used the term *intentional serendipity* to describe the overall practice of the ISTs in this study, which involved risk taking, persistence, and flexibility (Courduff et al., 2016).

The findings of Courduff et al. (2016) support the contention that exemplary technology integration practices are those that center the pedagogical and content related needs of students. This study also suggests that SpecEd ISTs' beliefs related to instructional technology may be critical factors contributing to their enacted teaching practices. According to the researchers, TPACK may be a useful framework to apply in SpecEd contexts but should be supplemented with knowledge of teacher beliefs and dispositions, as well as contextual factors (Courduff et al., 2016).

In another study, Anderson and Putnam (2020) explored the applied TPACK of eight SpecEd ISTs employed at a private university lab school for students with moderate disabilities. The SpecEd ISTs all indicated they were open to using technology for teaching and learning and had easy access to technology at their school. Data for this study was obtained through interviews and teaching observations which were recorded and transcribed. Data analysis revealed that the majority of coded items related to TK or TPK (less related to TCK and TPACK). Five ISTs were found to report high levels of confidence using technology for instruction, while three ISTs reported low confidence.

According to Anderson and Putnam (2020), the SpecEd ISTs' stances and beliefs about technology integration could be organized according to four main themes: (1) technology as inextricable from teaching, (2) technology as balanced with other materials, (3) technology as a tool, and (4) technology as a supplement. These categories were not mutually exclusive, and none was deemed to be superior to any other. Overall, the researchers found evidence for five benefits of using technology for instruction identified by the SpecEd ISTs: (1) differentiation, (2) varied representation, (3) motivation and engagement, (4) formative assessment, and (5) life skills. Several of the ISTs mentioned challenges related to technology use (e.g., technology not working as expected) and technological difficulties associated with inadequate levels of student or teacher TK. According to the researchers, the findings of this study support the use of personalized peer mentoring within ISTs' professional learning communities to provide PD targeting ISTs' TPACK development (Anderson & Putnam, 2020).

Much of the included literature on TPACK and SpecEd appeared to be exploratory in nature (e.g., Courduff et al., 2016), suggesting that TPACK research in SpecEd may still be in the beginning stages. Overall, what emerges from these studies is a vision (however incomplete) of what high quality technology integration practice might look like in SpecEd settings. For example, instructional technology use should be student centered (incorporating content that is of high interest to learners, and addresses students' individual needs and goals), and should be combined with evidence-based pedagogical strategies for SWDs. SETs should regularly monitor students' academic progress to evaluate the effectiveness of their technology integration practices. Technologies can be used to facilitate such progress monitoring. Technologies may also be used to address not only the academic needs of SWDs, but also their social-emotional, behavioral, and/or functional needs (Anderson et al., 2017).

It may be important that SETs incorporate explicit instruction techniques when introducing technologies to students, following a sequence beginning with clear direct instruction and teacher modeling, moving through guided practice, and ending with students' independent practice (Anderson et al., 2017). SETs should possess knowledge of how technology can be used for differentiation, varied representations of content, and instructional scaffolding. SETs may also demonstrate their TPACK through the skillful utilization of technology as a student reward or motivator. According to Marino et al. (2009), knowledge of assistive technologies may also factor into TPACK specific to SETs (including knowledge of more basic tools like screen readers, as well as knowledge of more complicated tools like augmentative and alternative communication technologies).

A synthesis of the findings enumerated above also suggest that SETs' attitudes and beliefs about technology may be important factors determining their actual technology integration practices. Teacher characteristics such as open-mindedness, resilience and perseverance may facilitate the exploration of instructional technologies, and enhance teachers' ability to work through technical challenges, eventually resulting in higher levels of TPACK (Anderson and Putnam, 2020).

Identified Research Gaps and Future Research Needs

A number of relevant research gaps and/or suggestions for future research were found in the recent K-12 OLT&L literature, as well as the recent K-12 education related TPACK research. Overall, there is a need for more academic research focusing on topics related to K-12 OLT&L (Martin et al., 2020; Natale & Cook, 2012). More specifically, identified gaps in the research include topics related to best practices in K-12 OLT&L (Arnesen et al., 2019; Borup, 2016a; Corry & Stella, 2012; Moore-Adams et al., 2016), online teaching competencies and qualifications (Pulham & Graham, 2018; Vasquez & Serianni, 2012), effective strategies for engaging parents in online learning (Borup, 2016b; Rice et al., 2019), and K-12 online SpecEd (Basham et al. 2013, 2016; Carnahan & Fulton, 2013; Corry & Stella, 2012; Crouse et al., 2018; Fernandez et al., 2016; Morgan, 2015; Rice & Carter, 2016; Sorensen, 2019; Vasquez & Serianni, 2012).

Additionally, there is a need for more research that utilizes a theoretical framework to explore issues related to K-12 OLT&L (Hu et al., 2019). More specifically, it has been suggested that future K-12 OLT&L research should make use of the TPACK framework (Ames et al., 2021; DiPietro et al., 2008), validating its use in new contexts (Archambault & Crippen, 2009; Cavanagh & Koehler, 2013) such as K-12 OLT&L. According to Ames et al. (2021), especially needed are quantitative and/or mixed-methods studies that utilize the TPACK framework to explore topics related to K-12 OLT&L.

Several of the studies reviewed explored teachers' TPACK in SpecEd contexts, although TPACK research in SpecEd still appears to be at an early stage. The majority of this research was qualitative and exploratory, limiting the generalizability of findings

(Anderson et al., 2017). There is a need for future research which uses quantitative and/or mixed methods designs to investigate the relationship between SETs' TPACK and teacher level variables which may be associated with high quality teaching practices. Additionally, there is a need for research that seeks to explore and describe best practices in K-12 OLT&L for SWDs, using TPACK as a theoretical framework (Courduff et al., 2016).

Summary of Findings from Similar Studies

Several studies included in the current review included findings that may be compared to the findings of this study. For example, a number of studies explored the relationship between teacher TPACK and other teacher level variables including (1) age, and (2) teaching experience. Several researchers reported findings suggesting that higher teacher age was negatively correlated with the technology related TPACK factors, and positively associated with non-technology related factors (Kazu & Erten, 2014; Koh et al., 2014a; Piret et al., 2018). However, two studies investigated this relationship and found no significant correlations between ISTs' age and self-reported TPACK (Demirok & Baglama, 2018; Hsu & Chen, 2018). Furthermore, Dong et al. (2015) found that ISTs with a mean age of 36.06 reported higher TK than PSTs with a mean age of 20.59. This finding is particularly interesting as it stands in direct contrast to the research suggesting younger teachers may have higher levels of TK.

A number of included studies reported findings suggesting that ISTs' teaching experience may be negatively correlated with one or more technology related dimensions of their TPACK (Akturk & Saka-Ozturk, 2018; Demirok & Baglama, 2018; Farrell & Hamed, 2017; Kazu & Erten, 2014; Koh et al., 2014a; Xie et al., 2017). However, three studies found that teaching experience was positively correlated with teacher TPACK in one or more domains (Chen & Jang, 2013; Hsu & Chen, 2018; Kazu & Erten, 2014). Additionally, two studies reported finding no evidence of differences in TPACK between educators with differing levels of experience (Martin, 2018; Ozudogru & Ozudogru, 2019).

In one qualitative study investigating the TPACK of a sample of special education teachers, Anderson and Putnam (2020) found that more experienced ISTs with low levels of technological confidence made statements related to TK and TCK more than other TPACK areas and were especially concerned about whether technology could support student growth. ISTs with medium levels of experience and high levels of technological confidence made statements related to the use of technology as a pedagogical tool (Anderson & Putnam, 2020).

CHAPTER THREE: METHODOLOGY

Purpose Statement

The purpose of this convergent design mixed-methods study (Creswell & Plano Clark, 2018) is to explore the TPACK of a sample of SETs working in K-12 online schools in the United States, to investigate the relationship between teachers' measured TPACK and other teacher level variables, and to obtain qualitative data on current online SpecEd teaching practices that may provide evidence of specific ways in which a sample of online SETs apply their TPACK in their work with students. Additionally, this study seeks to combine the quantitative and qualitative data seeking areas of convergence and/or divergence and looking for possible insights related to promising practices in the field of K-12 online SpecEd.

Research Design

This study makes use of a convergent design mixed-methods approach (Creswell & Plano Clark, 2018) to explore the self-assessed TPACK and self-reported teaching practices of a sample of K-12 online SETs working in U.S. public and charter schools. In this study, both the quantitative and qualitative data were collected concurrently, and the qualitative and quantitative data and methods are given equal weight. The qualitative data (participants' self-reported online teaching practices) were analyzed for evidence of teachers' applied TPACK. The quantitative data (measured TPACK and teacher level variables) were used to answer the quantitative research question, which entails reporting relevant descriptive statistics and determining the relationship between the criterion variable of participants' TPACK and the predictor variables of teacher age, online teaching experience, teacher education level, and teacher certification status. Finally, the qualitative and quantitative data were merged and analyzed together with an eye towards the identification of convergences and/or divergences of findings. The use of both quantitative and qualitative data is intended to provide a more comprehensive understanding of the research topic than could be achieved through the use of either type of data in isolation (Creswell & Plano Clark, 2018).

This study is rooted in a pragmatic philosophical worldview, which is "not committed to any one system of philosophy and reality" (Creswell & Creswell, 2018; p. 10), but rather seeks to explore a research problem from myriad angles and with a variety of tools. The pragmatic approach is therefore quite suitable for use in mixed-methods research (Creswell & Creswell, 2018). Table 1 provides a convenient summary of the research questions and associated data collection instruments and methods of data analysis for this study.

Table 1

Research Questions, Data Collection Instruments, and Data Analysis Methods

Research Question	Data Collection Instruments	Data Analysis Methods
What is the relationship between this sample of online SETs' measured TPACK and predictor variables of (1) age, (2) online teaching experience, (3) teacher education level, and (4) teacher certification status?	1. TPACK.xs Survey (Schmid et al., 2020; *See Appendix C*) 2. Demographic Survey (*See Appendix B)*	Multiple Regression Analysis
How do participants' responses to the open-ended qualitative items related to their online	1. Qualitative Questionnaire (*See Appendix D)*	Inductive and deductive coding cycles, seeking emergent themes. A priori codes consisted

teaching practices show evidence of their applied TPACK (including their use of high-leverage practices in online settings)?		of the seven standard TPACK factors.
How do the quantitative and qualitative findings related to participants' TPACK converge and/or diverge?	TPACK.xs Survey (Schmid et al., 2020; *See Appendix C*) 1. Demographic Survey (*See Appendix B)* 2. Qualitative Questionnaire (*See Appendix D)*	To answer this question, both the quantitative and qualitative data were merged for each participant in the NVivo QDAS program. Both data sets were analyzed for evidence of convergence and/or divergence (e.g., SET's qualitative responses were grouped and analyzed in terms of the quantitative variables).

Research Context

This study sought to explore the TPACK and teaching practices of SETs providing educational services in secondary (grades 6-12) online public and charter schools in the United States. This study therefore did not include data obtained from SETs working in primarily brick-and-mortar contexts, in schools only serving elementary aged students, or in private online schools or educational programs.

Researcher Subjectivity

As a SET who has worked in both traditional and online instructional contexts, I have both a personal and professional interest in the topic under study. As a SET, I am especially interested in identifying promising practices that can be implemented in online SpecEd contexts. As an academic in the field of educational technology, I aspire to conduct high-quality, reliable, bias-free research with a goal of knowledge production that can be utilized by other researchers and/or applied by practitioners. Nonetheless, I do acknowledge that some of my personal subjectivity may impact the way in which the research is carried out, particularly with respect to the analysis of qualitative data.

According to Attia and Edge (2017), reflexivity allows the qualitative researcher to develop awareness about their own practices, to become more attuned to the context of their study, to demonstrate integrity, and to produce trustworthy research. Therefore, I created and updated a research journal throughout the duration of the study, writing new entries after engaging in research activities. As an extension of this journaling, I attempted to engage in some analytic memoing during the qualitative analysis phase, a practice recommended by Miles et al. (2020). According to Birks et al. (2008), memoing during data analysis activities can help researchers communicate their decisions or conclusions to others, keep a reflexive attitude, and distill meaning from the data.

Ethics

The major ethical issues that must be considered when undertaking research projects are those listed in the Belmont Report of 1979: (1) Respect for persons, (2) beneficence, and (3) justice (Fiesler & Proferes, 2018). Every effort was made to abide by the letter and spirit of these principles while carrying out all research activities in this study.

The principle of respect for persons may be violated when sensitive personally identifiable information of participants is made publicly available by researchers. Therefore, the original data collected in this study was not made available to the public or to other researchers. Furthermore, identifiable information of participating SETs was protected.

No direct financial benefit was obtained by the researcher as a result of this research project. Furthermore, no sensitive student related data was collected or reported, and informed consent was obtained from all participants before any data is collected from them. As this research did involve human subjects, Boise State University Institutional Review Board approval was obtained before moving forward with any data collection or other part of the study.

Participants

The participants for this study are a sample of grade 6-12 SETs currently working in online or "virtual" public or charter schools in the United States. Given that the population of online SETs in the United States is not known, Roscoe's (1975) recommendations were used to determine the desired sample size: (1) the sample size should be more than 30 and less than 500, and (2) the sample size should be greater than 10 times the number of variables being studied in a multiple regression analysis ($n > 40$). Nonetheless, a larger sample size would enhance the generalizability and reliability of findings. Therefore, a target sample size (n) of 100 participants was determined for this study. However, only 46 participants were ultimately included in the study. While this number satisfies Roscoe's (1975) recommendations, it is on the lower end of the necessary sample size.

In order to recruit participants, a database consisting of gatekeeper contacts (e.g., SpecEd directors, administrators, lead teachers) at online public and charter schools listed on state education agency websites was compiled. An email was then sent to all online school and district contacts in the database, including a research participation request with links to informed consent materials and data collection instruments. The school and district level contacts were asked to forward the research participation request to all secondary (middle or high school) online SETs working in their organization. Both initial contact and follow up emails contained instructions for participation in the research study, and information related to an incentive for participation. The recruitment emails and the cover page for the digital survey included a statement making clear that only active SETs should respond to the survey, thereby excluding administrators or other non-teaching staff working in online schools. Using this approach (relying on gatekeepers), only a handful of participants were located. Therefore, a database of online SET contacts was created, and recruitment emails were sent directly to potential participants. The online survey was kept open for 5-6 weeks, at which point an acceptable number of responses had been obtained ($N = 46$).

The incentive for participation was a *Teachers Pay Teachers* (TPT) gift card worth $50 that was awarded at random to one participant who completed the entirety of the online survey. Instructions for obtaining the gift certificate incentive were delivered via email to the selected participant at the conclusion of the data collection period.

Data Collection and Analysis

The data obtained via the qualitative questionnaire was analyzed first (separate from the quantitative data), in order to avoid the possibility of the quantitative data influencing the researchers' qualitative data analysis (Linneberg & Korsgard, 2019). The qualitative data was imported into NVivo qualitative data analysis software (QDAS). Initially, deductive coding was used to locate evidence of SETs' applied TPACK in their responses (Miles et al., 2020). The deductive coding cycle involved assigning a priori codes derived from the TPACK framework. Specifically, the a priori codes utilized represent the seven standard TPACK factors: (1) TK, (2) PK, (3) CK, (4) TPK, (5) TCK, (6) PCK, and (7) TPCK. Initially, multiple rounds of deductive codes were assigned to a relatively small sample of the qualitative data. After ensuring that the coding process was achieving satisfactory results, the deductive coding was used across the larger body of qualitative data.

Following the deductive coding cycles, inductive codes were assigned to the segments of qualitative data previously coded for evidence of teachers' applied TPACK. This occurred firstly through two rounds of descriptive coding, in which codes were assigned to "chunks" of text to symbolically label these segments for meaning (Miles et al., 2020). Once descriptive coding was complete, a round of pattern coding was used, in which common relationships between chunks of items previously coded with descriptive labels were sought. These inductive coding cycles helped to further identify broader themes emerging from the data. Additionally, deductive coding helped the researcher to remain close to the data in order to capture new and/or unexpected patterns and insights (Linneberg & Korsgard, 2019).

In order to avoid the arbitrary coding of qualitative data (e.g., by word, line or paragraph), the researcher attempted to assign codes to chunks of text with coherent meaning (Chenail, 2012). From the codes, emerging themes were abstracted (these are reported in Chapter 4). Finally, themes and codes emerging from the qualitative data analysis were reviewed and used to develop research findings. Data displays such as networks and tables are provided in Chapter 4 to help communicate the results of the qualitative data analysis (Linneberg & Korsgard, 2019).

The quantitative portion of this research project made use of an online survey to administer a validated TPACK assessment (TPACK.xs; Schmid et al., 2020) to each participating SET, and to collect participant demographic data. The quantitative data was analyzed using standard multiple regression aided by the use of the IBM SPSS statistical software package. This technique was used to find a model that best predicts online SETs' mean TPACK scores (including their Total Mean TPACK, and mean scores for each TPACK factor) using the teacher-level predictor variables of: (1) age, (2) online teaching experience, (3) education level, and (4) certification status (Creswell & Creswell, 2018). In addition to the results of the multiple regression analysis, descriptive statistics are reported.

According to Keith (2019), the use of multiple regression analysis relies on four major assumptions: (1) a linear relationship exists between the criterion and predictor variables, (2) the errors of one case or observation are independent from other cases or observations, (3) the data should show evidence of homoscedasticity (equal variance; Osborne & Waters, 2002), and (4) errors should be normally distributed. Quantitative data checks were used to ensure the assumptions of multiple regression were met. These data checks are described in greater detail in Chapter 4. Notably, after completing the initial quantitative data checks, one participant's quantitative data were excluded from analysis after it was found to contain outlier data points that could have had an outsized impact on the results of the regression analysis (Morrow-Howell, 1994).

The qualitative and quantitative data were merged only during the final data analysis phase in order to answer the mixed-methods research question. During this phase, the quantitative data were added to the existing qualitative dataset in NVivo, so that the researcher could compare SETs' qualitative responses to their TPACK scores, and relevant teacher level demographics. The participants were then assigned to groups based on the quantitative variables of age, online teaching experience, certification status, and education level, which allowed the researcher to compare the qualitative responses of participants in different groups. In addition to this data integration, the qualitative and quantitative findings were compared during the mixed-methods analysis phase (Creswell & Plano Clark, 2018). Areas of convergence and divergence between the qualitative and quantitative data were identified, and are reported in Chapter 4, thus enhancing overall validity of the research project (Wray et al., 2007).

Instruments

All of the data for this study were collected via a digital survey administration consisting of three components: (1) a demographic survey, (2) a TPACK self-report survey (TPACK.vs; Schmid et al., 2020), and (3) a qualitative questionnaire developed by the researcher. A survey approach was selected for this study as it allows for quick data collection from a broad sample of participants and can be administered online. All of the instruments used to collect data from participants were administered using the same digital form. It was anticipated that participants would be able to complete all three components of the survey instrument within 30-60 minutes. Some identifying information was collected from participants for the purpose of ensuring that each participant submitted only one single copy of the digital form, for delivering the randomly awarded participation incentive, and for sharing the results of the research with participants (at their request). However, no readily identifiable participant information is being published as part of this study. Additional information regarding the three components of the digital form is provided below.

Demographic Survey

Participants were asked to provide certain demographic information including (1) age, (2) years of teaching experience, (3) years of online teaching experience, (4) highest level of education completed, (5) information regarding their certification status and teaching endorsements, and (6) state or U.S territory in which they are currently employed. Participants were also asked to share an email address and where they are currently employed, however any identifying or otherwise sensitive personal data were not analyzed for research purposes or reported with the research results. The demographic survey is located in Appendix B.

TPACK Survey

Participants were administered the TPACK.xs survey, which is an adaptation of the SPTKTT TPACK self-report survey (Schmidt et al., 2009) developed by Schmid et al. (2020; see Appendix C), who also drew upon the work of Chai et al. (2011) and Valtonen et al. (2017). The SPTKTT (Schmidt et al., 2009) has been used by researchers to measure the TPACK of both PSTs and ISTs (Xie et al., 2017), and in general and special education contexts (Alawadh et al., 2019; Tournaki & Lyublinskaya, 2014). The survey developed by Schmid et al. (2020) was adapted for use across content areas. The resulting 28-item, adapted TPACK survey was found to be valid and to measure the seven factors reliably (each factor was found to have a Cronbach Alpha value greater than 0.7).

The seven standard TPACK factors measured by this survey are: Technological knowledge (TK): knowledge that allows individuals to use rapidly changing digital technologies to efficiently and effectively accomplish a variety of tasks, and/or solve problems, (2) Pedagogical knowledge (PK): general knowledge of effective teaching practices, (3) Content Knowledge (CK): subject matter expertise, (4) Technological Pedagogical Knowledge (TPK): knowledge of how technologies can be used to impact teaching and learning, (5) Technological Content Knowledge (TCK): knowledge of the relationship between subject area content and technology, (6) Pedagogical Content Knowledge (PCK): knowledge of effective teaching practices for a given subject area, and (7) Technological, Pedagogical Content Knowledge (TPCK): deep knowledge of the relationships between technology, content and pedagogy that enables the implementation of effective technology integration practices (Koehler & Mishra, 2009).

Like the SPTKTT (Schmidt et al., 2009), the TPACK survey adapted by Schmid et al. (2020) is a 5-point Likert scale resulting in a scaled score for each factor. The survey results were used as quantitative data points in the multiple regression analysis.

<u>Qualitative Questionnaire</u>

Participants were also administered a digital version of a qualitative questionnaire developed by the researcher, which consists of 10 open-ended items that inquire about participants' online teaching practices. The first four questions were based on the four main practice areas identified as essential for effective SpecEd teaching in the HLPs: (1) collaboration, (2) assessment, (3) social/emotional/behavioral practices, and (4) instruction. Additional questions are related to promising online teaching practices identified in a review of the recent K-12 OLT&L literature. Another item asks what advice participants would share with new online SETs. A final item asks teachers to optionally share any additional information they deem to be important and related to effective online teaching practice. The qualitative questionnaire can be found in Appendix D.

Summary

This convergent design mixed methods study seeks to explore relationships between the self-reported TPACK, teacher level variables (age, online teaching experience, education level, and certification status), and self-reported teaching practices of a sample of K-12 online SETs working at public and charter schools in the United States. The study makes use of a pragmatic worldview and the TPACK theoretical framework.

Descriptive statistics and multiple-regression techniques were used to analyze the quantitative data, while inductive and deductive coding were used to analyze the qualitative data. The datasets were then merged and analyzed together looking for evidence of convergence and/or divergence of findings.

CHAPTER 4: RESULTS

Purpose Statement

The purpose of this convergent design mixed-methods study is to explore the TPACK and related teaching practices of a sample of SETs working in K-12 online schools in the United States from multiple perspectives to both characterize online SET practice in terms of TPACK, and identify factors associated with online SET TPACK. More specifically, this study includes a quantitative investigation into the relationship between SETs' measured TPACK and the teacher level variables of age, online teaching experience, education level, and certification status. Additionally, qualitative data reflecting online SET's self-reported teaching practices were analyzed for evidence of specific ways in which they apply their TPACK in their work with students. Lastly, both the quantitative and qualitative data were combined to identify areas of convergence and/or divergence.

Overview

The results of the present study are shared below. Firstly, information related to the organization of this chapter is provided, along with basic information related to the administration of the online survey and participant demographics. Secondly, the quantitative results are provided, including descriptive statistics for the TPACK.xs survey, as well as the multiple regression analysis results. Thirdly, the qualitative results are provided, including a discussion of how the qualitative data were coded for evidence of participants' applied TPACK, and the implementation of HLPs. Fourthly, the mixed-methods results are provided, including a discussion of convergences and divergences that were identified between the quantitative and qualitative data. Lastly, a brief summary of the results chapter is provided.

Sample Demographics

The sample for the present study consisted of 46 online (or "virtual") SETs working at fully or predominantly online secondary schools (grades 6-12, including transition age students) in the United States (See Table 2). While all 46 participants completed the TPACK.xs survey, as well as the majority of the demographic survey, only 34 of these participants also completed the qualitative questionnaire. Participants voluntarily completed the online survey after being recruited for the study via email. Participants' ages ranged from 31 to 71 ($M = 47$, $SD = 11.06$).

Table 2
States in which Participants are Employed

State	Number of Participants
Alabama	2
Arizona	2
California	1
Colorado	5
Florida	1
Georgia	3
Idaho	3
Kansas	1
Maine	1
Maryland	1
Michigan	3

Minnesota	7
Ohio	1
Oklahoma	1
Oregon	2
South Carolina	1
Tennessee	2
Utah	2
Washington	4
Wisconsin	2
Wyoming	1

Forty-five participants shared information related to their online teaching experience, which ranged from 1 to 16 years (*M* = 4.36, *SD = 3.86).* Forty-four participants shared information related to their special education teaching experience, which ranged from 1 to 29 (*M* = 11.8, *SD* = 6.64).

Regarding participants' highest educational level completed: three participants reported having achieved a doctoral degree (7%), 37 reported having achieved a master's degree (80%), while six participants reported having achieved a bachelor's degree (13%). Regarding participants' teaching certification status: six reported holding a professional level teaching certification (such as a National Board Certification; 13%), 39 reported holding a standard state issued teaching certification (85%), and one reported holding a provisional teaching certificate (2%). Forty-four participants reported holding a valid special education teaching endorsement, while two participants reported not holding such an endorsement.

Forty-Four participants shared information related to their place of employment: 31 reported working for a public school district (70%), 10 reported working for a charter school agency (23%), three reported working for a private company contracted with providing services for a public school (6%), and one reported working for a state education agency (2%). The majority of participants reported providing instructional and/or IEP case-management supports for students from more than one disability category, including students with both high- and low-incidence disabilities.

One of the participants who completed most of the TPACK.xs survey and qualitative questionnaire was nonetheless excluded from the quantitative analysis due to missing data points (representing independent variables), and because their case represented an outlier data point that could skew the regression results. Notably, this was the only participant who reported having a provisional teaching certificate.

Quantitative Results

The quantitative data was collected via an online administration of the TPACK.xs self-report instrument and a researcher-created demographic survey. The data collected from participants ($N = 46$) was analyzed using standard multiple regression analysis to answer the following research question:

> What is the relationship between this sample of online SETs' measured TPACK and predictor variables of (1) age, (2) online teaching experience, (3) teacher education level, and (4) teacher certification status?

TPACK.xs Response Statistics

A Cronbach Alpha score of 0.931 was calculated from participants' (*N*= 46) responses to the 28-item TPACK.xs survey. This demonstrates that the survey has good reliability and a high degree of internal consistency.

Overall, the participants reported relatively high scores for their overall mean TPACK (4.13; *SD* = 0.45), indicating that most participants agree that they can apply their TPACK effectively in their online special education teaching practice. Participants' PK emerged as the TPACK factor with the highest reported mean score (4.37), while TPK was found to be the TPACK factor with the lowest mean score (3.38). Table 3 shows participants' mean scores for each survey item, survey factor, and for the entire survey.

Table 3
Mean TPACK.xs Scores for Participant Sample

Item		M	SD
pk1	I can adapt my teaching based upon what students currently understand or do not understand.	4.59	0.62
pk2	I can adapt my teaching style to different learners.	4.52	0.69
pk3	I can use a wide range of teaching approaches in a classroom setting.	4.13	1.00
pk4	I can assess student learning in multiple ways.	4.23	0.95
PK Subscale		**4.37**	**0.66**
ck1	I have sufficient knowledge about my teaching subject.	4.54	0.50
ck2	I can use a subject-specific way of thinking in my teaching subject.	4.02	0.77
ck3	I know the basic theories and concepts of my teaching subject.	4.37	0.53

ck4	I know the history and development of important theories in my teaching subject.	3.96	0.63
CK Subscale		**4.22**	**0.46**

tk1	I keep up with important new technologies.	4.04	0.94
tk2	I frequently play around with technology.	4.02	0.93
tk3	I know a lot of different technologies.	4.20	0.78
tk4	I have the technical skills I need to use technology.	4.35	0.57
TK Subscale		**4.15**	**0.68**

pck1	I know how to select effective teaching approaches to guide student thinking and learning in my teaching subject.	4.39	0.65
pck2	I know how to develop appropriate tasks to promote students' complex thinking of my teaching subject.	4.22	0.70
pck3	I know how to develop exercises with which students can consolidate their knowledge of my teaching subject.	4.17	0.68
pck4	I know how to evaluate students' performance in my teaching subject.	4.46	0.66
PCK Subscale		**4.31**	**0.59**

tpk1	I can choose technologies that enhance the teaching approaches for a lesson.	4.15	4.15
tpk2	I can choose technologies that enhance students' learning for a lesson.	3.30	3.30
tpk3	I can adapt the use of the technologies that I am learning about to different teaching activities.	2.85	2.85
tpk4	I am thinking critically about how to use technology in my classroom.	3.22	3.22
TPK Subscale		**3.38**	**0.71**

tck1	I know how technological developments have changed the field of my subject.	4.15	0.67
tck2	I can explain which technologies have been used in research in my field.	4.28	0.72
tck3	I know which new technologies are currently being developed in the field of my subject.	4.20	0.75
tck4	I know how to use technologies to participate in scientific discourse in my field.	4.28	0.69
TCK Subscale		**4.23**	**0.59**

tpck1	I can teach lessons that appropriately combine my teaching subject, technologies, and teaching approaches.	4.35	0.64
tpck2	I can use strategies that combine content, technologies, and teaching approaches that I learned about in my coursework in my classroom.	3.98	0.91
tpck3	I can choose technologies that enhance the content of a lesson.	4.35	0.60
tpck4	I can select technologies to use in my classroom that enhance what I teach, how I teach, and what students learn.	4.41	0.62
TPCK Subscale		**4.27**	**0.57**
Total Mean TPACK = 4.13 (*SD* = 0.45)			

Note. Scale: 1 (*strongly disagree*) to 5 (*strongly agree*); *N* = 46.

Multiple Regression Analyses

A standard multiple regression analysis was run in SPSS statistics using the criterion variable of participants' (N = 45) self-reported TPACK scores and the predictor variables of participant age, online teaching experience, education level, and certification status. The categorical variables of education level and certification status were dummy coded such that they could be included in the regression analysis. Given that only three participants reported having earned a doctoral degree, these observations were merged with data from participants who reported having earned a master's level degree. This merging of data points allowed for the creation of a single dichotomous dummy variable called "graduate level education", where a value of 1 was used to represent participants who had achieved a master's level degree or higher, and a score of 0 was used to represent participants who had achieved only a bachelor's degree. Similarly, the categorical variable "certification status" initially allowed for three response options (provisional, standard, and professional certification), but was dummy coded into a single categorical variable called "standard certification" after excluding the only participant who reported having a provisional certificate from the regression analysis. This participants' data was excluded after having been identified as an outlier that could have an outsized impact on the results of the regression analysis.

The results of each regression analysis are provided in Table 4, with ANOVA statistics provided for each model in Table 5. In Model 1, participants' overall mean TPACK.xs survey scores were regressed over the predictor variables of teacher age, online teaching experience, education level, and certification status. This model was not found to be significantly predictive of participants' total mean TPACK.xs scores (Sig. = .554; adj. R^2 = -.022). Additionally, none of the predictor variable coefficients were found to be in the significant range ($p < 0.05$).

In Model 2, participants' Mean TK scores were regressed over the predictor variables of teacher age, online teaching experience, education level, and certification status. This model was found to be *nearly* significantly predictive of participants' mean TK (Sig. = .098), although the variance in mean TK explained by the model was very low (adj. R^2 = .092). Among the predictor variables, only participant age was found to be in the significant range ($p < 0.023$; $\beta = -.351$)

In Model 3, participants' Mean PK scores were regressed over the predictor variables of teacher age, online teaching experience, education level, and certification status. This model was not found to be significantly predictive of participants' mean PK (Sig. = .313; adj. R^2 = -.079). Similarly, none of the predictor variable coefficients were found to be significant, although participants' online teaching experience was relatively close to the significant range (*Sig.* = .092).

In Model 4, participants' Mean CK scores were regressed over the predictor variables of teacher age, online teaching experience, education level, and certification status. This model was not found to be significantly predictive of participants' mean CK (Sig. = .098; adj. R^2 = .021). Similarly, none of the predictor variable coefficients were found to be in the significant range.

In Model 5, participants' Mean TPK scores were regressed over the predictor variables of teacher age, online teaching experience, education level, and certification status. This model was not found to be significantly predictive of participants' mean TPK (Sig. = .381; adj. R^2 = .007). Neither were any of the predictor variable coefficients found to be in the significant range.

In Model 6, participants' Mean TCK scores were regressed over the predictor variables of teacher age, online teaching experience, education level, and certification status. This model was not found to be significantly predictive of participants' mean TCK (Sig. = .363; adj. R^2 = .01). Similarly, none of the predictor variable coefficients found to be in the significant range.

In Model 7, participants' Mean PCK scores were regressed over the predictor variables of teacher age, online teaching experience, education level, and certification status. This model was not found to be significantly predictive of participants' mean PCK (Sig. = .944; adj. R^2 = .018). Similarly, none of the predictor variable coefficients found to be in the significant range.

In Model 8, participants' Mean TPCK scores were regressed over the predictor variables of teacher age, online teaching experience, education level, and certification status. This model was not found to be significantly predictive of participants' mean TPCK (Sig. = .322; adj. R^2 = .019). Similarly, none of the predictor variable coefficients found to be in the significant range.

Given the lack of significant results obtained using only the predictor variables of participant age, online teaching experience, education level and certification status on the criterion variables of participants mean TPACK.xs scores, it was determined that participants' mean TK, PK, and CK scores (as measured by the TPACK.xs survey) would be included in subsequent regression models. These three factors were selected for inclusion as predictor variables because they represent the core knowledge domains on top of which the entire TPACK framework is built. Participants' mean TPK, TCK, PCK and TPCK scores were excluded as predictor variables for two primary reasons: (1) there was a concern that the inclusion of these factors as predictor variables might lead to an overfitting of the regression model, and (2) theoretically, the inclusion of these factors could lead to significant redundancy in the predictor variables given that they are built upon the more basic factors of TK, PK and CK.

In Model 9, participants' Mean TPCK scores were regressed over the predictor variables of teacher age, online teaching experience, education level, and certification status, mean TK, mean PK, and mean CK. This model was found to be significantly predictive of participants' mean TPCK (Sig. < .001) and was found to explain 58% of the variance in participants' mean TPCK scores (adj. $R^2 = .058$). Additionally, the following predictor variable coefficients were found to be in the significant range: (1) standard certification (Sig. = 0.23; β = 0.248), (2) participant age (Sig. = .043; β = -0.23), (3) mean CK (Sig. < .001; β = 0.427), and (4) mean PK (Sig. < .001; β = 0.434).

In Model 10, participants' Mean TK scores were regressed over the predictor variables of teacher age, online teaching experience, education level, and certification status, mean PK, and mean CK. This model was found to be significantly predictive of participants' mean TK (Sig. = 0.019) and was found to explain 20.9% of the variance in participants' mean TK scores (adj. $R^2 = .209$). Additionally, the following predictor variable coefficients were found to be in the significant range: (1) participant age (Sig. = 0.016; β = -0.353), and (2) mean PK (Sig. = 0.021; β = 0.338).

In Model 11, participants' Mean PK scores were regressed over the predictor variables of teacher age, online teaching experience, education level, and certification status, mean TK, and mean CK. This model was not found to be significantly predictive of participants' mean PK (Sig. = 0.164; adj. $R^2 = .08$). However, only the predictor variable coefficient for mean TK was found to be in the significant range (Sig. = 0.021; β = 0.393).

In Model 12, participants' Mean CK scores were regressed over the predictor variables of teacher age, online teaching experience, education level, and certification status, mean TK, and mean PK. This model was not found to be significantly predictive of participants' mean CK (Sig. = 0.238; adj. R^2 = 0.052). Similarly, none of the predictor variable coefficients were found to be in the significant range.

In Model 13, participants' Mean TPK scores were regressed over the predictor variables of teacher age, online teaching experience, education level, and certification status, mean TK, mean PK, and mean CK. This model was found to be significantly predictive of participants' mean TPK (Sig. = 0.004) and was found to explain 29.6% of the variance in participants' mean TPK scores (adj. R^2 = .296). Participants' mean TK was the only predictor variable coefficient found to be in the significant range (Sig. = 0.015; β = 0.392).

In Model 14, participants' Mean TCK scores were regressed over the predictor variables of teacher age, online teaching experience, education level, and certification status, mean TK, mean PK, and mean CK. This model was found to be significantly predictive of participants' mean TCK (Sig. < 0.001) and was found to explain 61.8% of the variance in participants' mean TCK scores (adj. R^2 = .618). Additionally, the following predictor variable coefficients were found to be in the significant range: (1) mean CK (Sig. = 0.007; β = 0.294), (2) mean PK (Sig. = .003; β = .331), and (3) mean TK (Sig. < .001; β = 0.472).

In Model 15, participants' Mean PCK scores were regressed over the predictor variables of teacher age, online teaching experience, education level, and certification status, mean TK, mean PK, and mean CK. This model was found to be significantly predictive of participants' mean PCK, although the significance level was marginal (Sig. = 0.049). Model 15 was found to explain 16.9% of the variance in participants' mean

PCK scores (adj. R^2 = .169). Additionally, the following predictor variable coefficients were found to be in the significant range: (1) mean PK (Sig. = 0.039; β = 0.329), and (2) mean CK (Sig. = .029; β = 345).

Table 4
Multiple Regression Results

Model	R	R Square	Adjusted R Square	Std. Error
1[a]	0.267	0.071	-0.022	0.451
2[b]	0.138	0.019	-0.079	0.688
3[c]	0.417	0.174	0.092	0.655
4[d]	0.331	0.11	0.021	0.453
5[e]	0.312	0.097	0.007	0.696
6[f]	0.317	0.1	0.01	0.588
7[g]	0.136	0.018	-0.08	0.61
8[h]	0.328	0.108	0.019	0.557
9[i]	0.804	0.646	0.58	0.365
10[j]	0.563	0.317	0.209	0.611
11[k]	0.453	0.205	0.08	0.636
12[l]	0.426	0.182	0.052	0.446
13[m]	0.639	0.408	0.296	0.586
14[n]	0.824	0.679	0.618	0.365
15[o]	0.549	0.301	0.169	0.535

a. Predictor Variables: (1) Age, (2) OL Teaching Exp., (3) Standard Cert, (4) Graduate Edu; Criterion Variable: Mean TPACK (average of all TPACK.xs items)
b. Predictor Variables: (1) Age, (2) OL Teaching Exp., (3) Standard Cert, (4) Graduate Edu; Criterion Variable: Mean TK
c. Predictor Variables: (1) Age, (2) OL Teaching Exp., (3) Standard Cert, (4) Graduate Edu; Criterion Variable: Mean PK
d. Predictor Variables: (1) Age, (2) OL Teaching Exp., (3) Standard Cert, (4) Graduate Edu; Criterion Variable: Mean CK

e. Predictor Variables: (1) Age, (2) OL Teaching Exp., (3) Standard Cert, (4) Graduate Edu; Criterion Variable: Mean TPK
f. Predictor Variables: (1) Age, (2) OL Teaching Exp., (3) Standard Cert, (4) Graduate Edu; Criterion Variable: Mean TCK
g. Predictor Variables: (1) Age, (2) OL Teaching Exp., (3) Standard Cert, (4) Graduate Edu; Criterion Variable: Mean PCK
h. Predictor Variables: (1) Age, (2) OL Teaching Exp., (3) Standard Cert, (4) Graduate Edu; Criterion Variable: Mean TPCK
i. Predictor Variables: (1) Age, (2) OL Teaching Exp., (3) Standard Cert, (4) Graduate Edu, (5) Mean TK, (6), Mean PK, (7) Mean CK; Criterion Variable: Mean TPCK
j. Predictor Variables: (1) Age, (2) OL Teaching Exp., (3) Standard Cert, (4) Graduate Edu, (5) Mean PK, (6), Mean CK; Criterion Variable: Mean TK
k. Predictor Variables: (1) Age, (2) OL Teaching Exp., (3) Standard Cert, (4) Graduate Edu, (5) Mean TK, (6), Mean CK; Criterion Variable: Mean PK
l. Predictor Variables: (1) Age, (2) OL Teaching Exp., (3) Standard Cert, (4) Graduate Edu, (5) Mean TK, (6), Mean PK; Criterion Variable: Mean CK
m. Predictor Variables: (1) Age, (2) OL Teaching Exp., (3) Standard Cert, (4) Graduate Edu, (5) Mean TK, (6), Mean PK, (7) Mean CK; Criterion Variable: Mean TPK
n. Predictor Variables: (1) Age, (2) OL Teaching Exp., (3) Standard Cert, (4) Graduate Edu, (5) Mean TK, (6), Mean PK, (7) Mean CK; Criterion Variable: Mean TCK
o. Predictor Variables: (1) Age, (2) OL Teaching Exp., (3) Standard Cert, (4) Graduate Edu, (5) Mean TK, (6), Mean PK, (7) Mean CK; Criterion Variable: Mean PCK

Table 5
ANOVA Statistics for All Regression Models

Model	Sum of Squares	df	Mean Square	F	Sig.
1[a]	0.622	4	0.156	0.756	0.554
2[b]	3.625	4	0.906	2.109	0.098
3[c]	0.366	4	0.092	0.193	0.94
4[d]	1.014	4	0.253	1.232	0.313
5[e]	2.084	4	0.521	1.077	0.381
6[f]	1.542	4	0.386	1.115	0.363
7[g]	0.279	4	0.07	0.188	0.944
8[h]	1.504	4	0.376	1.209	0.322

9[i]	9.009	7	1.287	9.665	<0.001
10[j]	6.602	6	1.1	2.943	0.019
11[k]	3.961	6	0.66	1.634	0.164
12[l]	1.679	6	0.28	1.405	0.238
13[m]	8.745	7	1.249	3.642	0.004
14[n]	10.432	7	1.49	11.166	<0.001
15[o]	4.567	7	0.652	2.279	0.049

a. Predictor Variables: (1) Age, (2) OL Teaching Exp., (3) Standard Cert, (4) Graduate Edu; Criterion Variable: Mean TPACK (average of all TPACK.xs items)
b. Predictor Variables: (1) Age, (2) OL Teaching Exp., (3) Standard Cert, (4) Graduate Edu; Criterion Variable: Mean TK
c. Predictor Variables: (1) Age, (2) OL Teaching Exp., (3) Standard Cert, (4) Graduate Edu; Criterion Variable: Mean PK
d. Predictor Variables: (1) Age, (2) OL Teaching Exp., (3) Standard Cert, (4) Graduate Edu; Criterion Variable: Mean CK
e. Predictor Variables: (1) Age, (2) OL Teaching Exp., (3) Standard Cert, (4) Graduate Edu; Criterion Variable: Mean TPK
f. Predictor Variables: (1) Age, (2) OL Teaching Exp., (3) Standard Cert, (4) Graduate Edu; Criterion Variable: Mean TCK
g. Predictor Variables: (1) Age, (2) OL Teaching Exp., (3) Standard Cert, (4) Graduate Edu; Criterion Variable: Mean PCK
h. Predictor Variables: (1) Age, (2) OL Teaching Exp., (3) Standard Cert, (4) Graduate Edu; Criterion Variable: Mean TPCK
i. Predictor Variables: (1) Age, (2) OL Teaching Exp., (3) Standard Cert, (4) Graduate Edu, (5) Mean TK, (6), Mean PK, (7) Mean CK; Criterion Variable: Mean TPCK
j. Predictor Variables: (1) Age, (2) OL Teaching Exp., (3) Standard Cert, (4) Graduate Edu, (5) Mean PK, (6), Mean CK; Criterion Variable: Mean TK
k. Predictor Variables: (1) Age, (2) OL Teaching Exp., (3) Standard Cert, (4) Graduate Edu, (5) Mean TK, (6), Mean CK; Criterion Variable: Mean PK
l. Predictor Variables: (1) Age, (2) OL Teaching Exp., (3) Standard Cert, (4) Graduate Edu, (5) Mean TK, (6), Mean PK; Criterion Variable: Mean CK
m. Predictor Variables: (1) Age, (2) OL Teaching Exp., (3) Standard Cert, (4) Graduate Edu, (5) Mean TK, (6), Mean PK, (7) Mean CK; Criterion Variable: Mean TPK
n. Predictor Variables: (1) Age, (2) OL Teaching Exp., (3) Standard Cert, (4) Graduate Edu, (5) Mean TK, (6), Mean PK, (7) Mean CK; Criterion Variable: Mean TCK

o. Predictor Variables: (1) Age, (2) OL Teaching Exp., (3) Standard Cert, (4) Graduate Edu, (5) Mean TK, (6), Mean PK, (7) Mean CK; Criterion Variable: Mean PCK

Ultimately, five models were found to be significant ($p < 0.05$), as shown in Table 6. In the column headed "Significant Predictor Variables", the sign (positive or negative) after each predictor shows the direction of the observed relationship between each significant predictor variable and the criterion variable.

Table 6
Significant Standard Regression Models

Criterion Variable	**Predictor Variables**	**Adj. R Square**	***SE***	***Sig.***	***Significant Predictor Variables***
Mean TPCK	(1) Age, (2) online teaching experience, (3) standard certification, (4) graduate level education, (5) mean TK, (6) mean PK, and (7) mean CK	0.58	0.365	<0.001	(1) standard certificate + (2) age - (3) mean CK + (4) mean PK +
Mean TPK	(1) Age, (2) online teaching experience, (3) standard certification, (4) graduate level education, (5) mean TK, (6) mean PK, and (7) mean CK	0.296	0.586	0.004	(1) mean TK +
Mean TCK	(1) Age, (2) online teaching experience, (3) standard certification, (4) graduate level education, (5) mean TK, (6)	0.618	0.365	<0.001	(1) mean CK + (2) mean PK + (3) mean TK +

	mean PK, and (7) mean CK				
Mean PCK	(1) Age, (2) online teaching experience, (3) standard certification, (4) graduate level education, (5) mean TK, (6) mean PK, and (7) mean CK	0.169	0.535	0.049	(1) mean PK + (2) mean CK +
Mean TK	(1) Age, (2) online teaching experience, (3) standard certification, (4) graduate level education, (5) mean PK, and (6) mean CK	0.209	0.611	0.019	(1) age - (2) mean PK -

Checking the Assumptions of Multiple Regression

According to Keith (2019), the use of multiple regression analysis relies on four major assumptions: (1) a linear relationship exists between the criterion and predictor variables, (2) the errors of one case or observation are independent from other cases or observations, (3) the data should show evidence of homoscedasticity (equal variance; Osborne & Waters, 2002), and (4) errors should be normally distributed.

An examination of partial regression plots was made between all continuous variables. From a visual inspection of these graphs, it was determined that an approximately linear relationship exists between all predictor and criterion variables, thereby satisfying the assumption of linearity.

A Durbin-Watson statistics was calculated for each significant regression model (where $p < 0.05$) to assess the independence of errors (autocorrelation). All of the Durbin-

Watson statistics were found to be in the acceptable range (1.5-2.5) suggesting a lack of autocorrelation.

Homoscedasticity, or equal variance, was checked by plotting the regression standardized residuals against the regression standardized predicted values for each regression model that was found to be significant. Visual inspection of these plots did reveal some linear patterns in the data, although overall there did not appear to be any significant funneling or fanning indicative of heteroscedasticity. Additionally, all standardized residuals and predicted values were found to lie between 3 and -3, which is indicative of homoscedasticity.

Nonetheless, given that the visual inspection of plots is a somewhat subjective way to assess homoscedasticity, a Pearson correlation coefficient was also calculated between the standardized predicted values and absolute value of the standardized residuals for each significant regression model ($p < 0.05$). All coefficients were found to be less than 0.7, indicating that the data do not evidence significant heteroscedasticity.

Normal distribution of residuals was assessed by visually inspecting the histograms and P-P plots of each significant regression model ($p < 0.05$). Although there was some apparent deviation from the normal curve and expected value lines, the data appear to be approximately normally distributed.

Overall, it was determined that the quantitative data met the four basic assumptions of multiple regression analysis described by Keith (2019).

Qualitative Results

Qualitative data were collected through the administration of an online questionnaire consisting of 10 items related to secondary online SETs' professional practice. The qualitative data collected from participants ($N = 34$) was analyzed to facilitate answering the following research question:

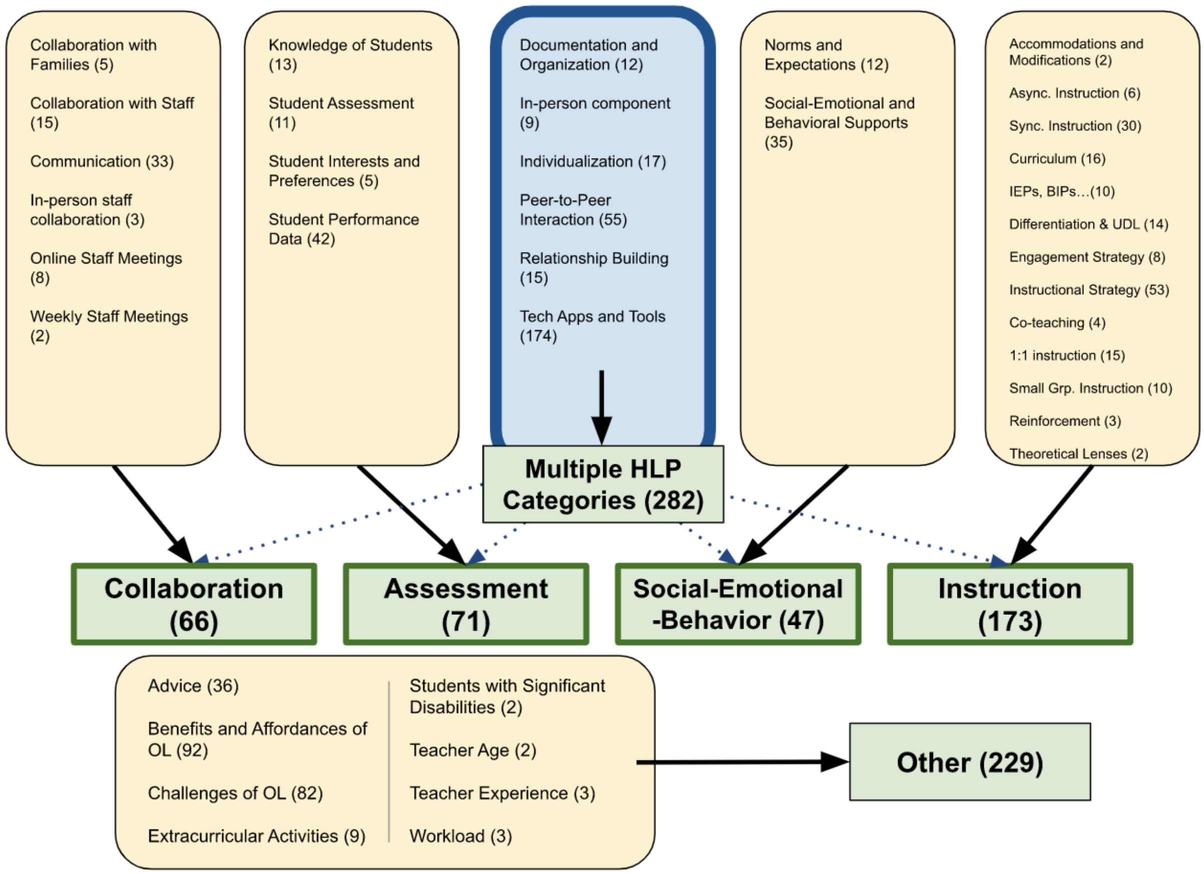
> How do participants' responses to the open-ended qualitative items related to their online teaching practices show evidence of their applied TPACK (including their use of high-leverage practices in online settings)?

The qualitative data was first coded using a priori codes representing the seven standard TPACK factors of TK, CK, PK, TPK, TCK, PCK and TPCK. Chunks of meaningful text that showed evidence of a participant's applied TPACK were labeled with these seven codes. Table 7 shows the number of items that were labeled with each a priori code. TPK was the most frequently assigned code, followed by PK. No items were coded with the CK label, and only a small number of items were coded with the PCK label. Finally, a moderate number of items were coded using the TK, TCK, and TPCK labels.

After all the qualitative data had been coded for evidence of participants' applied TPACK, multiple cycles of deductive coding were used. First, descriptive coding was used, resulting in a list of 39 codes which captured a common element or meaning shared by multiple chunks or "items" of qualitative data. These descriptive codes were then merged into six groupings of related pattern codes to further abstract the data (see Figure 3). The first four groupings of pattern codes represented the HLP categories of (1) collaboration, (2) assessment, (3) social-emotional behavior supports, and (4) instruction. A fifth pattern code represented aspects of participants' online teaching practice that reflected the implementation of strategies from multiple HLP categories. For example, the descriptive code "In person component" included coded data discussing participants' in-person collaborative activities with colleagues, as well as in-person instructional supports offered to students. A final pattern code was labeled simply "other", and contained descriptive codes related to participants' online teaching practices that were deemed interesting, but only tangentially related to applications of participants' TPACK.

Figure 3

A Visual Representation of Descriptive and Pattern Codes



The qualitative data was subjected to a final round of coding in which the researcher looked for evidence of participants' implementation or adaptation of one or more of the 22 specific HLPs in descriptions of their online teaching practice. Table 8 shows the number of previously coded items that were also coded as evidence of a given HLP. From this it can be seen that evidence was found in participants' qualitative responses for the implementation of 21 out of 22 HLPs. The only HLP for which no evidence of implementation could be found was HLP 10 ("Conduct functional behavioral assessments to develop individual student behavior support plans").

Table 7
Number of Items in Participants' Qualitative Responses Coded for Each TPACK Factor

TPACK Factor	Number of Items Coded
TK	28
PK	102
CK	0
TPK	189
TCK	32
PCK	9
TPCK	26

Table 8
Number of Qualitative Items Coded to Each HLP

High Leverage Practice	Number of Items Coded
1. Collaborate with professionals to increase student success	31
2. Organize and facilitate effective meetings with professionals	6
3. Collaborate with families to support student learning and secure needed services	23

4. Use multiple sources of information to develop a comprehensive understanding of a student's strengths and needs	55
5. interpret and communicate assessment information with stakeholders to collaboratively design and implement educational programs	1
6. Use student assessment data, analyze instructional practices, and make necessary adjustments that improve student outcomes	16
7. Establish a consistent, organized, and respectful learning environment	27
8. Provide positive and constructive feedback to guide students' learning and behavior	8
9. Teach social behaviors	18
10. Conduct functional behavioral assessments to develop individual student behavior support plans	0
11. Identify and prioritize long- and short-term learning goals	3
12. Systematically design instruction toward specific learning goals	13
13. Adapt curriculum tasks and materials for specific learning goals	9
14. Teach cognitive and metacognitive strategies to support learning and independence	4
15. Provide scaffolded supports	15
16. Use explicit instruction	3
17. Use flexible grouping	22
18. Use strategies to promote active student engagement	21
19. Use assistive and instructional technologies	93
20. Provide intensive instruction	4
21. Teach students to maintain and generalize new learning across time and settings	2

22. Provide positive and constructive feedback to guide students' learning and behavior	5

To answer the qualitative research question, a coding matrix query was used to locate items that were coded to both a given TPACK factor, and a particular descriptive code. These data points were then analyzed for evidence of specific ways in which participants' (as a whole) showed evidence of their applied TPACK through their qualitative responses. Direct quotes are presented in the sections below to illustrate the relationship between participants' specific TPACK factors and the aspects of their teaching practice described in the qualitative data.

<u>Qualitative Evidence of Participants' Applied TK</u>

In total, 28 items in participants' qualitative responses were coded with the TK label. Participants' qualitative responses showed evidence of their applied TK through discussions of various technological apps and tools that did not include specific reference to how these tools could be leveraged for pedagogical purposes, or to support learning in specific content areas.

For example, one participant wrote simply: "IXL, NWEA, Splashlearn" in response to a question asking specifically about the use of student data in participants' teaching practice. It may be reasonable to assume that this participant's response suggests the application of their TCK (e.g., knowledge of specific technological programs that can be leveraged to teach specific content areas) or TPK (e.g., the use of specific technological platforms to collect student performance data that would subsequently be used to inform instruction). However, the researcher decided to code pieces of data such as this with only the TK factor, given that the participant did not elaborate on how these particular technological apps and tools might specifically be leveraged in their teaching practice.

In another example, a participant answering Q1 of the qualitative questionnaire responded with “text messaging, email, phone calls, [and] conference calls.” Again, it could be inferred that this participant uses these technologies to effectively communicate student progress updates with stakeholders, and/or to collaborate with colleagues and families in developing students’ educational plans, indicating an application of the participants’ TPK. However, the literal response from the participant only references the technology itself, and not how the technology is utilized for a particular pedagogical purpose. Therefore, such data points were coded only with the TK factor.

Overall, the data suggests that this sample of online SETs drew upon their TK when selecting digital technologies and web-based platforms for the purposes of collaboration, assessment and instruction. Participant responses referenced numerous digital tools utilized in their practice. Many digital tools and platforms were referenced multiple times and by multiple participants (e.g., IXL, Jamboard, Prodigy, Google Classroom, etc…).

TK and HLPs

Some qualitative evidence was found supporting the assertion that participants drew upon their TK in their implementation of HLPs in the online setting. More specifically, it was found that participants’ knowledge of video conferencing platforms supported their implementation of HLP 1 (“collaborate with professionals to increase student success”) and HLP 2 (“organize and facilitate effective meetings with professionals”). Participants’ knowledge of web-based assessment instruments supported their implementation of HLP 4 ("use multiple sources of information to develop a comprehensive understanding of a student's strengths and needs"). Finally, the implementation of HLP 19 ("use assistive and instructional technologies") was supported by participants' knowledge of learning management systems (LMS), web-based instructional platforms (e.g., "IXL", "Read Naturally"), online games used for learning activities (e.g., "Prodigy", "Kahoot"), web-based communication tools (e.g., "email", "Remind"), cloud storage and web-based organizational tools (e.g., Google Drive, OneDrive), and their knowledge of digital accommodations and/or accessibility tools.

<u>Qualitative Evidence of Participants' Applied PK</u>

PK was the 2nd most frequently used a priori code after TPK. 102 items in participants' qualitative responses were coded under the PK label. Many participants' qualitative responses included descriptions of strategies used to develop consistent instructional routines, promote active student engagement and participation, and to create a positive and safe learning environment, including through the integration of social-behavioral supports and/or learning games into instruction. The PK factor was used to code pieces of data indicating participants' use of such pedagogical strategies without reference to a particular technological tool or medium.

In some cases, items coded with the PK factor referenced specific social-emotional learning (SEL) curricula, or strategies that participants leveraged with the specific intent of supporting students' SEL. For example, one participant wrote that they "begin each class with a 'Zones of Regulation' check in, which students have shared that they enjoy." It could be argued that SEL constitutes a "content area" in itself, and as such, this and similar items might better fit under the heading of PCK. However, for the purposes of the present study, the "content" of K-12 schooling refers to Language Arts (inclusive of Reading and Writing), Mathematics, Science, Social Studies and other academic subject areas. By contrast, supporting student engagement in learning (including through the use of social behavior supports) will be considered a *pedagogical* strategy that can be used across content areas, suggesting the presence of a teachers' PK.

PK and HLPs

Qualitative evidence was found suggesting that participants' applied PK supported their implementation of HLP 1 ("collaborate with professionals to increase student success"), as shown by their participation in regularly held department meetings, professional learning communities (PLCs), and their collaborative work and co-planning with general education teachers and other school staff (e.g., social workers).

Participants' implementation of HLP 3 ("collaborate with families to support student learning and secure needed services") was supported by their applied PK as evidenced by frequent progress updates sent home to parents, participation in meetings with families aimed at better understanding their unique needs, and collaborative work with families to improve student behavior and performance in school.

The qualitative data also suggests that participants may draw upon their applied PK in their implementation of HLP 4 ("use multiple sources of information to develop a comprehensive understanding of a student's strengths and needs"). Implementation of HLP 4 was indicated by participants' use of standardized tests, curriculum-based measures, teacher created assessments, formative data collection practices, use of observation data, reviews of students' prior academic records, the tracking of student attendance and participation, and collecting student data through informal conversations with families.

The implementation of HLP 6 ("use student assessment data, analyze instructional practices, and make necessary adjustments that improve student outcomes") was also found to be supported by participants' applied PK. Participants implemented HLP 6 primarily through the use of varied forms of assessment data to inform individualized instruction delivered to students.

Participants also demonstrated their applied PK through the implementation of HLP 7 ("establish a consistent, organized, and respectful learning environment") by setting clear expectations for learning, using strategies to build positive relationships with students (e.g., "community circles"), collaborating with students to define class norms, and using consistent and predictable instructional routines.

The implementation of HLP 8 ("provide positive and constructive feedback to guide students' learning and behavior") was also found to be supported by participants' applied PK. For example, one participant described using frequent "check-ins" with students to provide social-behavioral feedback, and to discuss students' thoughts, feelings and concerns.

Similarly, it was found that the implementation HLP 9 ("teach social behaviors") was supported by participants' applied PK. Participants described using social stories, scenario-based instruction, and specific SEL curricula (e.g., "Zones of Regulation", "Social Thinking", "Sown to Grow", "Character Strong") to teach prosocial behavior to students. Some participants also mentioned teaching coping and resilience strategies and engaging in positive behavior modeling to support students' improved social behavior.

Participants' applied PK was also found to support their implementation of HLP 11 ("Identify and prioritize long- and short-term learning goals"), as evidenced by their use of student assessment data to determine individualized learning goals. Similarly, evidence for the implementation of HLP 12 ("systematically design instruction toward specific learning goals") was found in participants' descriptions of planning lessons targeting students' IEP goals and using teacher-made curricular materials aligned to the general education learning standards. One participant also specifically mentioned the use of evidence-based instructional practices which they relied upon to help students meet their individual goals.

Participants' implementation of HLP 13 ("adapt curriculum tasks and materials for specific learning goals") was also found to be informed by their applied PK. Evidence for the implementation of HLP 13 was found in participants' reported use of modified assignments, use of co-teaching models to provide students with specially designed instruction (SDI), use of varied instructional tasks for individual students, and alteration of pacing requirements for individual students.

Participants' applied PK was also found to support their implementation of HLP 14 ("teach cognitive and metacognitive strategies to support learning and independence"). For example, one participant described delivering strategy instruction for reading (e.g., teaching students to "re-read" the passage and identify root words). Another participant described modeling their own metacognitive thinking for students, what is sometimes called a "think aloud" in the world of metacognitive strategy instruction (Traga Philippakos, 2021).

The implementation of HLP 15 (“provide scaffolded supports”) was similarly found to be supported by participants’ applied PK. Evidence for the implementation of HLP 15 was found in
participants’ reported use of anchor charts, sentence starters, graphic organizers, visual aids, leveled texts, and assignment checklists during instruction. Additionally, some participants described providing students with (teacher created) notes, using additional examples during instruction, and breaking large assignments into smaller parts or “chunks”.

One participant mentioned the use of “direct instruction” in their online teaching practice, suggesting at minimum a level of declarative PK that supported their implementation of HLP 16 (“use explicit instruction”). While some other participants described using “modeling” procedures during teaching, there were no other clear descriptions of explicit instruction techniques found in the qualitative data.

It was also found that participants’ applied PK supported their implementation of HLP 17 (“use flexible grouping”), primarily through the delivery of instruction in both 1:1 (individual) and small group contexts. Participants’ implementation of HLP 18 (“use strategies to promote active student engagement”) also was found to draw upon their applied PK, as evidenced by strategies to provide choice within lessons (e.g., through the use of a “choice board”), the use of positive reinforcement and verbal praise during lessons, the integration of learning games into instruction, the application of Universal Design for Learning (UDL) techniques to meet the needs of all learners, and the use of curricular materials with other active or “engaging” elements.

Additional qualitative evidence suggested that one participant drew upon their applied PK in implementing HLP 20 ("provide intensive instruction") through the use of repetitive instruction (providing students with opportunities to practice a given skill multiple times). Some participants also drew upon their applied PK in implementing HLP 22 ("provide positive and constructive feedback to guide students' learning and behavior"), evidenced by discussions related to participants' use of verbal praise for positive student performance, and the use of redirection (guiding students towards positive, on-task behaviors).

Qualitative Evidence of Participants' Applied CK

No items were coded under the CK heading, as nothing was found in participants' qualitative responses in which their knowledge of a particular academic content area was discussed without reference to either a pedagogical approach, or a technological tool or instructional platform. Rather, participants' CK can be inferred from the responses that were coded under the intermediate factors of TCK and PCK, as well as the TPCK factor.

Qualitative Evidence of Participants' Applied TPK

More items were coded to the TPK factor than any other TPACK factor (189 in total). Participants' qualitative responses suggested the application of their TPK through the selection and use of specific technological tools and platforms for assessment of student performance and growth. For example, one participant wrote that "things like google form assessments are both a time saver and a great way to assess online. If students cannot read the questions, you can record yourself saying the questions." Several participants mentioned using assessment data obtained via technology-based platforms to individualize students' learning experiences. For example, one participant reported using "the ULS curriculum for daily practice…for each student based on their personal profile. The profile reflects their reading level and differentiated instruction level."

Participants' also showed evidence of their applied TPK through the use of technological tools to organize, analyze and disseminate student performance data with stakeholders. As one participant wrote: "I have a google sheet that has all my students in a separate sheet. All my data and communications are noted on this sheet. It is shared with my principal, so she can access it at any time." Another participant wrote the following: "I keep digital files on each student that include a log of our weekly meetings, the district test results in math and reading, a portfolio with artifacts of their work samples from their various courses, snips of their responses to adobe connect polls they participate in, observe dashboard data of their current scores in their courses and current scores on weekly assignments with their teacher's feedback, I use excel spreadsheets to monitor student engagement in my courses and in their other courses to know what student prefer and what they avoid."

Additionally, participants demonstrated their applied TPK through the use of technologies to communicate and collaborate with colleagues and families. For example, one participant wrote: "I use the phone to reach out to parents/families and colleagues to get answers to my questions or to explain how a student is doing in their classes." Some participants also specifically mentioned the use of online calendar functions to organize IEP team meetings.

Participants' collaborations with staff around their use of instructional technologies, inclusive of both virtual and in-person collaboration, also showed evidence of their applied TPK. For example, one participant wrote that they collaborate with another special education teacher "to develop methods of instruction, build hands on content for distribution [*sic*], and learn/ problem solve weakness in technology [*sic*] …several times a week through TEAMS." Another participant stated that they meet with their online teaching colleagues "monthly in person to work together on building our technology usage [*sic*] and methods."

Participants also discussed the implementation of accommodations and scaffolding for students with disabilities in the online learning environment, also reflecting their applied TPK. According to one participant, "a surprising amount of accommodations originally designed to be met in person can also be met online." Several participants also mentioned the use of technologies to make instructional materials and activities more accessible for students with disabilities, with one writing they provide students with "many resources…in written and audio/visual format." One participant also mentioned their practice of providing students with "direct links to resources" during synchronous instruction, which may be used to streamline lesson delivery and reduce students' cognitive load during lessons.

Some teachers discussed how they set up their own teaching workstation, with reference to specific kinds of hardware. For example, one participant wrote that they "work off of four computers, [and] eight screens connected to one keyboard and mouse. This helps me monitor the classes my students are in and to be able to instruct classes with multiple [*sic*] students."

Participants also demonstrated their applied TPK through the use of technologies to deliver specially designed instruction meant to address students' IEP goals and individual learning needs. One participant reported providing "slide decks for students and families that are targeting their IEP goals", while another reported meeting with students "multiple times a week per their IEP to work on their IEP goals in a small group or 1:1 setting via our online platform".

Participants' incorporation of specific instructional technologies to promote student engagement also showed evidence of their applied TPK. For instance, one participant wrote that they like to use the online learning games from "Prodigy…because they act like video games [*sic*] and teach students so much."

Participants' decisions to use particular kinds of student groupings for instruction in the online learning environment also seemed to be informed by their TPK. A number of participants discussed the use of breakout rooms within video conferencing platforms to facilitate flexible student grouping. One participant described such a strategy: "WebEx has break-out rooms, where we can send specific students so that they can work together on an assignment."

Participants' use of technologies for the development and delivery of general instructional materials, both synchronous and asynchronous, also seemed informed by their applied TPK. For example, one participant wrote that they "teach using Nearpod" which "allows…students to draw/write using their touchscreens. It also allows them to have multiple choice options as well as the ability to type out answers." Several participants also mentioned the use of instructional video in their practice, making use of teacher-created content as well as instructional videos they located online.

A number of participants mentioned using metadata obtained through a learning-management system (LMS), or other technological platform, to track student engagement and/or “attendance” in online school, with the specific pedagogical goal of promoting optimal levels of student engagement.

Several participants demonstrated their applied TPK when referencing the use of peer-to-peer collaborative learning practices aided by the use of technology. One participant wrote: “When my kiddos use guided notes or learn a new technology trick - I have them teach the tool to the other students.”

Participants also demonstrated their applied TPK through discussing the importance of establishing norms, routines and class expectations in ways that are unique to the online learning environment, or that otherwise entail the use of specific technologies. For example, one participant wrote that they “respect students’ emotional needs by allowing them the privacy to have their cameras off during live google meets.” Interestingly, some participants expressed differing opinions on the question of whether to allow students to turn off their cameras during synchronous instruction or not, with one writing that “ALL students must have their camera turned on”.

TPK and HLPs

The qualitative evidence suggested that participants’ TPK informed their implementation of various HLPs in the online learning environment. For example, participants’ demonstrated evidence of their TPK in implementing HLP 1 (“collaborate with professionals to increase student success”) through the use of video-conference software, text messaging, email, online chat, and phone calls to collaborate with colleagues. Additionally, one participant mentioned participating in in-person meetings with colleagues to focus on improving their use of technology. Participants’ implementation of HLP 2 (“organize and facilitate effective meetings with professionals") was also found to be informed by their TPK, as evidenced by their use of online calendar tools to coordinate team meetings, and the use of video conferencing platforms to host IEP meetings.

Participants also demonstrated their applied TPK through their implementation of HLP 3 ("collaborate with families to support student learning and secure needed services"). For example, participants reported collaborating and communicating with families via text messages, phone calls, emails and video conferencing platforms. Collaboration and communication with families largely centered on discussions of student progress in school and/or the development of strategies to promote greater student success.

Participants were also found to draw upon their TPK in order to implement HLP 4 ("use multiple sources of information to develop a comprehensive understanding of a student's strengths and needs"). Participants reported the use of various digital tools for assessment of student performance: digital forms-based quizzes, data from web-based instructional platform, the use of quiz "games" for formative assessment during synchronous instruction (e.g., "Kahoot!"), and the collection of observational student data during synchronous instruction via video conferencing.

The implementation of HLP 5 ("interpret and communicate assessment information with stakeholders to collaboratively design and implement educational programs") also was found to be informed by the TPK of one participant who reported using a digital spreadsheet to share relevant student data with their administrators.

The implementation of HLP 6 ("use student assessment data, analyze instructional practices, and make necessary adjustments that improve student outcomes") was similarly related to one participants' TPK, as evidenced through their reported practice of adjusting students' instructional paths based upon performance data collected via web-based tools.

Participants also drew upon their TPK to implement HLP 7 ("establish a consistent, organized, and respectful learning environment"). For example, participants reported setting clear student expectations for videoconferencing (e.g., camera on or off, mute or unmute microphone), using various digital tools to communicate information to students, being intentional about the design of their LMS course page, and using various technologies (e.g., spreadsheets, cloud storage drive) to organize materials such as digital lesson plans, student data, and communication logs. Participants' implementation of HLP 8 ("provide positive and constructive feedback to guide students' learning and behavior") also was found to draw upon their TPK, as evidenced by their use of video conferencing tools to provide feedback on student behavior.

The qualitative data also suggested that participants drew upon their TPK to implement HLP 12 ("systematically design instruction toward specific learning goals") through the use of technology to design and develop instruction aligned with students IEP goals. Additionally, participants demonstrated their applied TPK through the implementation of HLP 13 ("adapt curriculum tasks and materials for specific learning goals"). This occurred through the provision of digital accommodations for students (e.g., screen readers), as well as through participants' application of the UDL principles (providing students with multiple means of representation, engagement and expression) with the aid of instructional technologies.

Participants' implementation of HLP 15 ("provide scaffolded supports") was also found to be informed by their TPK through the provision of direct links to instructional resources for students, and the use of digital accommodations (e.g., speech-to-text software).

Participants' responses also indicated that they drew upon their TPK to implement HLP 17 ("use flexible grouping"). This was evidenced by participants' reported use of peer-to-peer learning strategies to build students' technological knowledge and skill, and the use of "breakout rooms" within video conferencing platforms to facilitate peer-to-peer collaboration. Additionally, participants reported using both 1:1 and small group instruction during synchronous lessons with students.

Participants also were found to draw upon their applied TPK to implement HLP 18 ("use strategies to promote active student engagement") via the use of interactive digital presentations, digital games, and emojis (as an engaging mode of communication) during instruction, as well as by using video conferencing tools to meet with families to discuss strategies for increasing student engagement in learning. Additionally, some participants reported providing opportunities for students to share and interact with peers via video conferencing during synchronous instruction.

Evidence that participants' implementation of HLP 19 ("use assistive and instructional technologies") was informed by their applied TPK was found in their reported use of specific web-based applications for delivering instruction, the use of a document camera during synchronous lessons, and the sharing of instructional videos with students. Additionally, participants reported using several advanced features within video conferencing platforms during instruction (e.g., screen share, digital whiteboard, annotations), using digital tools to create assessments / rubrics, integrating digital learning games into instruction, using digital textbooks (e-books) for instruction, and making use of digital student information system (SIS) for tracking attendance and student grades. One participant even referenced their use of an advanced computer hardware setup for teaching online (e.g., using multiple computers / screens used during synchronous lessons such that both the video conferencing software and instructional platforms could be seen simultaneously).

Participants' qualitative responses also suggested that their implementation of HLP 20 ("provide intensive instruction") was informed by their TPK. For example, one participant reported providing students with intensive instruction related to the use of course required technologies. Another participant reported using the LMS to provide students with "additional" individualized instructional materials.

Finally, the qualitative data suggested that some participants' implementation of HLP 22 ("provide positive and constructive feedback to guide students' learning and behavior") was informed by their TPK, as evidenced by their reported use of technology to provide feedback on assignments (e.g., comments within shared documents).

Qualitative Evidence of Participants' Applied TCK

Of the 32 items in participants' responses coded under the TCK heading, the large majority were exclusively concerned with participants' knowledge of web-based instructional platforms and/or curricular materials that could be used to provide SWDs instruction and intervention in particular content areas. More specifically, the majority of items coded to TPK referenced participants' knowledge of tech tools that could be leveraged to support students in the core academic areas of math and reading. For example, one participant wrote that "for math, there is desmos and mathway to help identify how to solve the math problems and how to explain it as well. There's also the aspect of the built-in [*sic*] calculator." Another participant reported using "Lexia" for "individualized reading curriculum in word study, grammar, and comprehension". However, a few coded items referenced online curricular materials that could be used to support learning in other content areas. For example, one teacher referenced using "Next Gen Personal Finance" with her students, and another reported using digital content from "Mystery Science".

TCK and HLPs

The qualitative evidence suggested that participants applied their TCK to implement HLP 19 ("use assistive and instructional technologies"). For example, participants reported using specific web-based educational platforms for instruction in specific content areas (e.g., math, reading, writing, science), and for the assessment of student skills in specific content areas (e.g., math, reading, writing).

Qualitative Evidence of Participants' Applied PCK

Only nine items in participants' qualitative responses were coded under the PCK label, making PCK the 2nd least frequently used a priori code. Nonetheless, some participants demonstrated their applied PCK through the use of instructional strategies to teach certain content areas without reference to a technological medium used for instructional delivery. For example, one participant wrote that they like to teach their math students "shortcuts [*sic*]...which probably makes me a pariah in the eyes of math educators…but sometimes kids need shortcuts [*sic*]." Another participant wrote of their approach to literacy instruction: "words being taught through highlighting and read alouds are very helpful for my students as is just having a conversation about what they would write."

Participant discussions related to assessment strategies used to collect student performance data in specific content areas also showed evidence of their applied PCK. For example, one participant wrote that they "use monthly CBM fluency probes, MCaP math probes, sight word probes, and writing probes" with their students.

<u>PCK and HLPs</u>

Participants applied PCK was found to contribute to their implementation of various HLPs, including HLP 4 ("use multiple sources of information to develop a comprehensive understanding of a student's strengths and needs"), which participants demonstrated through their reported use of observation data for student assessment in mathematics, content specific teacher created math assessments, informal data collection practices (formative assessment) during science lessons, and use of curriculum based assessments (CBMs) for measuring student performance in math, reading and writing.

Some participants demonstrated the application of their PCK towards the implementation of HLP 6 ("use student assessment data, analyze instructional practices, and make necessary adjustments that improve student outcomes"). This occurred through the use of student assessment data to inform math instruction (e.g., lessons aligned with students' individual goals). Additionally, one participant drew upon their applied TCK to implement HLP 12 ("systematically design instruction toward specific learning goals") by reportedly developing their own original math curriculum for use with SWDs.

Some qualitative evidence indicated that participants' implementation of HLP 14 ("teach cognitive and metacognitive strategies to support learning and independence") was informed by their PCK. For example, one participant discussed their use of strategy instruction to support the development of students' math problem solving abilities.

Evidence for participants' implementation of HLP 15 ("provide scaffolded supports"), which was also found to be informed by participants' applied PCK, consisted of one participant's reported practice of highlighting key words during literacy instruction, and reading passages outloud for students who struggle with decoding. One participant also discussed engaging in writing conferences and discussions with individual students, demonstrating an application of their PCK towards the implementation of HLP 22 ("provide positive and constructive feedback to guide students' learning and behavior").

Qualitative Evidence of Participants' Applied TPCK

26 items in participants' qualitative responses were coded under the TPCK label. Participants' applied TPCK was inferred through their discussions of technological tools and/or web-based platforms used to assess student performance in particular content areas. For example, one participant reported using "Virtual Job Shadow" for "online transition planning assessments". Another participant wrote of their practice: "I teach special education math so I use the whiteboard in the live classroom to have the student work the problem to see where the errors are happening in their math." Additionally, participants' showed evidence of their applied TPCK through the use of such assessment data in the planning of content area instruction. One participant discussed their attempt to align their instruction to content area learning standards: "I start with individualized online placement testing from things like IXL and Lexia, and then go from there to set up

personalized recommendations and lessons for each student, following state standards as best I can."

Participants also demonstrated their applied TPCK through the use of technological tools to deliver content area instruction, with specific references to certain pedagogical techniques and strategies utilized. For example, one participant reported the following: "I use an ipad to explain math concepts. I use Notability to work out math problems and ingrain steps used to solve problems. I can share on my Google Classroom and present my screen. Students can see me work out problems in real time and I have several colors to use to distinguish important steps or concepts." Participants' discussions of such pedagogical strategies included references to specific types of instructional groupings and settings used in the online learning environment. One participant wrote that they "work one on one with students who need help with their online Math and English lessons."

Another participant discussed the leveraging of technology-based accommodations and/or scaffolds to support student learning in particular content areas, writing that they help their students make use of "text to speech [tools] to access a passage and speech to text [tools] to answer comprehension questions."

TPCK and HLPs

Participants' qualitative responses contained evidence of ways in which they drew upon their TPCK in the implementation of a number of HLPs. For instance, it was found that participants' TPCK supported their implementation of HLP 4 ("use multiple sources of information to develop a comprehensive understanding of a student's strengths and needs") through the use of online assessments to measure students' performance of specific content area skills, as well as by collecting student performance data through observation during synchronous content area lessons (with the aid of a video-conferencing platform and shared digital whiteboard).

Participants implemented HLP 6 (“use student assessment data, analyze instructional practices, and make necessary adjustments that improve student outcome”) through adjustments made to individual students’ technology-mediated synchronous math instruction, informed by students’ general education assignment grades. This was similarly found to be informed by participants’ applied TPCK.

HLP 11 (“identify and prioritize long- and short-term learning goals”) was identified as another professional practice implemented with the aid of participants’ TPCK. In this case, evidence of implementation was found in one participant’s reported delivery of technology-mediated instruction targeting students’ individual goals aligned with state learning standards (in specific content areas). Likewise, one participant described their efforts to use technological tools in the design of instruction aligned with state learning standards (in specific content areas), demonstrating an application of their TPCK towards the implementation of HLP 12 (“systematically design instruction toward specific learning goals”).

> Qualitative evidence was also found suggesting that participants drew upon their TPCK in implementing HLP 15 (“provide scaffolded supports”). For example, some participants mentioned the use of technology-based accommodations to support student performance in reading and writing.

Evidence for the implementation of HLP 16 (“use explicit instruction”) was found for one participant who applied their TPCK by delivering direct (explicit) math instruction to students synchronously via videoconference, with the use of a digital whiteboard. Some participants reported using video-conferencing platforms to deliver 1:1 and/or small-group math instruction and/or tutoring to students, providing evidence for both their applied TPCK and their likely implementation of HLP 17 ("use flexible grouping").

Finally, a significant amount of qualitative evidence demonstrated how participants applied their TPCK in implementing HLP 19 ("use assistive and instructional technologies"). This occurred through participants' reported use of iPads or Tablets to model math problem solving strategies for students during synchronous instruction, use of digital whiteboards to deliver content area instruction, and delivery of content area instruction through video-conferencing platforms. Additionally, several participants reported the use of technology-based accommodations to support student performance in specific content areas, the use of web-based instructional resources to provide students with skill practice in specific content areas, and the use of online assessments to measure students' performance of specific content area skills. One participant also specifically mentioned their use of a document camera to deliver math instruction in the online learning environment.

Challenges Identified by Participants

Participants' qualitative reports identified a number of challenges they faced in their online special education teaching practice. The most persistent challenge identified by participants was related to difficulties promoting sufficient levels of student engagement in online learning. For example, one participant shared that "the biggest challenge are those students who refuse to attend [Google] meets or log onto their computers to work." Similar sentiments were shared by many participants. A small number of participants also mentioned challenges related to students' academic integrity, with one participant sharing that it can be difficult "ensuring someone else isn't doing the work."

Another significant challenge identified by participants related to perceived difficulties developing students' social and behavioral skills in the online learning environment. One participant reported feeling that SWDs in online school were "miss[ing] out on social interaction opportunities."

Participants also reported challenges related to what they felt was an excessive workload. Some participants reported having large caseloads of students, and several participants expressed their belief that planning for online instruction requires more time than planning for brick-and-mortar instruction. One participant expressed feeling that they were being negatively impacted by the excessive screen time required by their job.

Some participants expressed concerns that the needs of SWDs (especially students with significant, low-incidence disabilities) were not being adequately met in the online learning environment. One participant mentioned the lack of hands-on materials needed by some SWDs, and a general lack of accessible curricular materials. Another participant reported challenges in providing meaningful instruction to students with limited communication skills. Several participants mentioned challenges related to student deficits in executive functioning and/or technological skills, skills which these participants felt were critical factors for success in online learning.

Additionally, some participants indicated challenges related to parents or caregivers that they felt were insufficiently involved or invested in the education of their students. However, it should be noted that many participants shared favorable sentiments about the role parents and caregivers played in students' online learning.

Mixed-Methods Results

After both the qualitative and quantitative data had been analyzed separately, they were merged in NVivo QDAS so that both data sets could be analyzed concurrently to answer the following research question:

> How do the quantitative and qualitative findings related to participants' TPACK converge and/or diverge?

The concurrent analysis of the qualitative and quantitative data in NVivo did not lead to the identification of sufficient evidence to support any new mixed methods findings. Therefore, the findings from the qualitative and quantitative data analyses were compared to identify areas of convergence and divergence, which are discussed below and summarized in Table 9.

Convergent Results

The first convergent result identified was related to evidence suggesting a significant and negative relationship between participant age and TK that was found in both the qualitative and quantitative data. More specifically, the results of the multiple regression analyses indicating that participant age was a significant predictor of mean self-reported TK and TPCK scores were found to converge with qualitative reports from online SETs over the age of 61, who reported challenges in their professional practice related to their knowledge and/or use of technology. For example, one participant (age 64) shared the following:

> My fellow teachers know that technology confounds me. I rely on them for new information and support but have to admit that it often confuses me, as I didn’t grow up with technology like they did (I am old - they are young). My students know that I am not highly proficient in the VERY many technologies out there for math, so they are very good about helping me.

Another participant (aged 71), when asked specifically about challenges related to their online teaching practice, wrote that technology “doesn’t always do what it’s supposed to”. While this response could seem like somewhat of a truism, it is interesting to note that this was the only participant who explicitly mentioned technological struggles when asked about the challenges faced in their online teaching role.

A second convergent finding related to estimations of participants’ PK. The quantitative data showed that participants’ mean PK scores were higher than any other mean TPACK factor. Similarly, a large amount of qualitative evidence suggested that participants’ online special education teaching practices were largely informed by their applied PK.

<u>Divergent Results</u>

Evidence of divergence between the quantitative and qualitative results was found in terms of the assessment of participants’ TPK. Participants’ qualitative responses provided a large amount of evidence for applications of TPK in their online teaching practice, and specifically in their implementation of a number of HLPs. In fact, TPK was the a priori code used most frequently to label participants’ responses during the qualitative analysis phase. However, TPK had the lowest total mean score for participants who completed the TPACK.xs survey. In other words, although participants' self-reports indicated that they felt (overall) a relative lack of confidence with respect to their TPK, qualitative descriptions of their online teaching practice revealed that they relied heavily on their applied TPK to deliver instructional services and supports for SWDs.

Additionally, it was found that participants' TPACK.xs scores showed that they (collectively) had a relatively high amount of confidence with respect to their CK (4.22). However, no qualitative items explicitly suggesting the application of participant CK to their teaching practice was found during the a priori coding stage, and only a moderate number of items were coded to the PCK, TCK and TPCK labels (TPACK factors related to, or built upon, CK).

Table 9
Mixed-Methods Findings

	Convergent results	Divergent results
Quantitative results	1. The results of the multiple regression analysis showed that participant age significantly and negatively predicted self-reported mean TK and mean TPCK. 2. Participants' mean PK scores were higher than any other mean TPACK factor score.	1. Participants' mean TPACK.xs scores showed that self-reported mean scores were lowest for the TPK factor. 2. The mean CK for participants who completed the TPACK.xs survey was relatively high (4.22).
Qualitative results	1. Qualitative responses from two participants over the age of 61 referencing professional challenges related to TK and technology use. 2. A significant amount of qualitative evidence was found suggesting the application of participants'	1. TPK was the most frequently used a priori code used to analyze participants' qualitative responses. 2. No qualitative items were coded under CK; only a moderate number of items were coded to either PCK, TCK, or TPCK.

	PK in their online special education teaching practice.	

Table Adapted from the Work of Morgan (2019).

Summary

This convergent design mixed methods study was used to explore the self-reported and applied TPACK of a sample of online secondary SETs in the United States (N = 46). Both qualitative and quantitative data were collected through the administration of an online survey instrument, consisting of a demographic survey, the TPACK.xs self-report instrument, and a qualitative questionnaire developed by the researcher. Descriptive statistics related to the sample are reported above.

Participants reported strong overall TPACK scores (M = 4.13; SD = 0.45), as measured by the TPACK.xs survey instrument. Participants rated themselves highest in the area of PK (M = *4.37;* SD = 0.66), and lowest in the area of TPK (M = 3.38; SD = 0.71). One participant's quantitative survey data was excluded from the regression analysis after being identified (by a high leverage value) as representing an outlier data point. Notably, this was the only participant to report having a provisional teaching certificate. Standard multiple regression analyses were conducted during the quantitative data analysis phase to find models significantly predictive of participants' (N = 45) overall mean TPACK.xs scores, and scores for the discrete TPACK factors, from the predictor variables of participant age, online teaching experience, education level, and certification status. None of these models were found to be significant. Therefore, participants' self-reported mean TK, mean PK, and mean CK scores were added to the regression models as predictor variables. With these additions, five significant regression models were found, with the criterion variables of (1) TPCK, (2) TPK, (3) TCK, (4) PCK, and (5) TK.

Several coding cycles (including the use of a priori codes, descriptive coding, and pattern coding) were used to analyze the qualitative data. The qualitative results demonstrated that participants applied their TPACK to their online teaching practice in a variety of ways, including through the implementation of 21 out of 22 HLPs. The findings related participants' applications of TPACK in their implementation of specific HLPs are explored in greater detail in Chapter 5: Discussion. The qualitative data analysis indicated that participants relied heavily on their TPK and PK in their online teaching practice, and to a lesser extent on their TK, TCK, PCK, and TPCK. However, no qualitative evidence was found indicating the direct application of participants' CK in their online teaching practice.

After the qualitative and quantitative data had been analyzed, both data sets were merged and analyzed concurrently for evidence of convergence and/or divergence. One convergent result related to the relationship between participant age and TK: The multiple regression results showed that participant age had a significant and negative statistical relationship with self-reported mean TK and mean TPCK, while the qualitative data contained evidence that two participants over the age of 61 faced challenges in their online teaching practice related to either their relative lack of TK, or an application of their TK. Similar qualitative evidence was not found among any of the younger participants' (age 31 – 60) reports. Another convergence was identified in that both the quantitative and qualitative data suggested high levels of participant PK.

The mixed-methods data analysis also yielded two divergent results: (1) the lowest self-reported mean TPACK factor score for participants was TPK, while the qualitative data suggested that TPK is the TPACK factor participants most often applied in their teaching practice, and (2) participants' self-reported mean CK was relatively high (M = 4.22; SD = 0.46), while no direct evidence of participants' applied CK was found in the qualitative data.

CHAPTER FIVE: DISCUSSION

Purpose Statement

The purpose of this convergent design mixed-methods study is to explore the TPACK and related teaching practices of a sample of SETs working in K-12 online schools in the United States from multiple perspectives in order to both characterize online SET practice in terms of their TPACK, and to identify factors associated with online SET TPACK. More specifically, the research included a quantitative investigation into the relationship between teachers' measured TPACK and the teacher level variables of age, online teaching experience, education level, and certification status. Additionally, qualitative data reflecting online SET's self-reported teaching practices were analyzed for evidence of specific ways in which online SETs apply their TPACK in their work with students. Lastly, both the quantitative and qualitative data were combined to identify areas of convergence and/or divergence.

Discussion of Research Findings

This section includes a discussion of the main research findings, organized by method type (quantitative, qualitative and mixed methods) and research questions. In each case, the research findings are discussed with reference to the previous literature.

Quantitative Findings and Discussion

Quantitative methods were used to answer the following research question:

> What is the relationship between this sample of online SETs' measured TPACK and predictor variables of (1) age, (2) online teaching experience, (3) teacher education level, and (4) teacher certification status?

Standard multiple regression techniques were used to find models that significantly predicted participants' ($N = 45$) overall self-reported TPACK, and mean scores for each TPACK factor (as measured by the TPACK.xs survey) from the predictor variables of participant age, online teaching experience, education level, and certification status, mean TK, mean PK, and mean CK. Notably, after excluding one participant's responses from the regression analysis (because this case was identified as a statistical outlier that could skew the results of the analysis), no participants whose responses were included in the multiple regression analysis reported possessing a provisional teaching certificate.

Five models were found which significantly predicted participants' mean TPACK scores from the predictor variables of age, online teaching experience, certification status, education level, mean TK, mean PK, and mean CK. Each of these findings are discussed in greater detail below.

Significant Regression Model with Criterion Variable of Mean TPCK

Firstly, it was found that the predictor variables of participant age, online teaching experience, certification status, education level, mean TK, mean PK, and mean CK were able to explain 80% of the variance in participants' mean TPCK scores. However, among the predictor variables, only certification status, age, mean CK and mean PK were found to be significant. More specifically, it was found that participants with a standard certificate reported significantly higher mean TPCK scores than participants with a professional level certificate. This finding is somewhat surprising: considering the initiative and demonstrated teaching skills necessary to earn a professional level certification, one might expect that such teachers would report above average TPCK.

However, no contrasting or similar findings were located in the literature review related to the relationship between teacher certification status and TPCK, therefore it is difficult to elaborate on the practical significance of this finding.

Additionally, increases in participant age were associated with lower mean TPCK scores. This finding is consistent with several prior studies reporting a negative correlation between teacher age and TK, or other technology related TPACK factor (Kazu & Erten, 2014; Koh et al., 2014a; Piret et al., 2018). However, this finding is inconsistent with the results of existing research reporting either (1) no significant correlation between teacher age and TPACK (Demirok & Baglama, 2018; Hsu & Chen, 2018), or (2) a positive correlation between teacher age and TK (Dong et al., 2015). It should be noted, however, that the study conducted by Dong et al. (2015) was comparing the TK of two groups of teachers: one group consisting of PSTs with a mean age of 20.59, and the other group consisting of ISTs with a mean age of 36.06. The generalizability of Dong et al.'s (2015) findings may be limited because comparisons were being made between PSTs and ISTs, and because older teachers (e.g., over the age of 60) may have been underrepresented in the sample. In the present study, teacher age was not found to be positively and significantly correlated with non-technology related TPACK domains (e.g., PK, CK), as some prior research has found (Kazu & Erten, 2014; Koh et al., 2014a; Piret et al., 2018).

It is possible that correlations observed between age and technology related TPACK might be better understood with reference to the generation to which teachers belong (for which age is a proxy). Individuals born after approximately 1980 can be considered "digital natives" (Prensky, 2001), as they were exposed to and used digital technologies throughout their entire lives, beginning in early childhood. It may be that digital native educators possess or report higher levels of technology related TPACK than their "digital immigrant" counterparts (educators born before approximately 1980).

Additionally, it was found that participants' mean CK, and mean PK scores were positively associated with mean TPCK. This is not surprising, given that TPCK is assumed to represent an overlapping knowledge area between teacher TK, CK and PK. Therefore, this finding offers partial support for the TPACK framework, or at least the factor validity of the TPACK.xs survey instrument. However, it is somewhat surprising that mean TK was not also among the significant predictors of mean TPCK.

Significant Regression Model with Criterion Variable of Mean TPK

Secondly, it was found that the predictor variables of age, online teaching experience, certification status, education level, mean TK, mean PK, and mean CK explained about 29.6% of the variance in participants' mean TPK scores. However, among the predictor variables, only mean TK was found to be significant. Specifically, mean TK was found to be positively associated with mean TPK. This finding offers partial support for the TPACK framework and TPACK.xs factor structure, which posit that TPK is built upon TK and PK. It is, however, surprising that mean PK was not found to be a significant predictor of participant TPK.

Significant Regression Model with Criterion Variable of Mean TCK

Thirdly, it was found that the predictor variables explained about 61.8% of the variance in participant TCK. However, only mean CK, mean PK, and mean TK were found to be significant predictors, all evidencing a positive relationship with mean TCK. This finding offers partial support to the TPACK framework and factors structure of the

TPACK.xs survey, as TCK is assumed to represent the overlap of TK and CK. However, it is surprising that mean PK was a significant predictor of mean TCK, given that the TCK factor is not meant to encompass any aspect of PK in the TPACK framework.

Significant Model with Criterion Variable of Mean PCK

Fourthly, it was found that the predictor variables explained about 16.9% of the variance in participants' mean PCK scores. However, only mean PK and mean CK were found to be significant predictors, both evidencing a positive relationship with mean PCK. This finding offers strong support for the factor structure of PCK, which is assumed to be built exclusively upon PK and CK.

Significant Model with Criterion Variable of Mean TK

Lastly, it was found that the predictor variables of age, online teaching experience, certification status, education level, mean PK and mean CK explained about 20.9% of the variance in participants' mean TK scores. However, only the predictors of age and mean PK were found to be significant, both evidencing a negative relationship with mean TK. The finding that participant age may be negatively associated with participant TK is consistent with some previous research findings (Kazu & Erten, 2014; Koh et al., 2014a; Piret et al., 2018), and similar to the finding discussed above related to the relationship between participant age and mean TPCK. However, the finding that participant PK may be negatively predictive of participant TK is more difficult to explain. While some previous research has found that older teachers may, on average, have lower levels of TK and higher levels of PK than younger teachers, participant age was not found to be a significant predictor of mean PK in the current study. Therefore, we cannot explain the finding that mean PK negatively predicts mean TK in the current study simply with reference to participant age.

Discussion of Non-Significant Findings

Somewhat surprisingly, participants' online teaching experience was not found to be predictive of mean TPACK scores in this study. This finding stands in at least partial contrast with previous research reporting a significant negative correlation between teacher experience and one or more technology-related TPACK domains (Akturk & Saka-Ozturk, 2019; Demirok & Baglama, 2018; Farrell & Hamed, 2017; Kazu & Erten, 2014; Koh et al., 2014a; Xie et al., 2017). Additionally, this finding contrasts with prior research indicating that IST teaching experience may be significantly and positively correlated with overall TPACK (Chen & Jang, 2013), PK (Hsu & Chen, 2018), and PCK (Kazu & Erten, 2014). However, the findings from the current study are consistent with those reported by both Ozudogru and Ozudogru (2019), and Martin (2018), who found no significant relationship between teacher experience and TPACK.

One possible (and perhaps, partial) explanation for the discrepant findings related to teacher experience and TPACK might have to do with a potentially spurious relationship existing between teacher age, teacher generation, and teaching experience. In other words, it may be that some prior studies reporting a negative correlation between teaching experience and TPACK were at least partially indicating a relationship between teacher age (or generation) and TPACK. This is simply because on average one might expect older teachers to possess more teaching experience than younger teachers, and because older teachers are more likely to be from a generation of "digital immigrants" (Prensky, 2001). However, in the current study, the predictor variable used was not total teaching experience, but online teaching experience. It is possible that online teaching experience is less correlated with teacher age than total teaching experience, simply because K-12 online teaching and learning is still in the developing phase. For this reason, many current online SETs may be teachers with significant brick and mortar experience who have only recently embarked on their online teaching career (as was the case for a number of participants in the current study).

It was also somewhat surprising that participant education level was not found to be a significant predictor of participant overall TPACK or any individual mean TPACK factor score. This finding contrasts with some previous research which found that higher levels of teacher education were associated with higher self-reported TPACK (Farrell & Hamed, 2017). However, it is possible that the small sample size in the current study could at least partially account for this discrepancy.

Qualitative Findings and Discussion

Qualitative methods were used to answer the following research question:

> How do participants' responses to the open-ended qualitative items related to their online teaching practices show evidence of their applied TPACK (including their use of high-leverage practices in online settings)?

Participants' responses to the qualitative questionnaire were coded for evidence of their applied TPACK using an a priori coding scheme consisting of the seven standard TPACK factors (TK, PK, CK, TPK, TCK, and TPCK). The qualitative data suggested that participants applied their TPK to their online teaching practice significantly more than any other factor. Participants were also found to heavily rely on their TPK when implementing HLPs in the online learning context. Additionally, PK emerged as a significant factor participants applied in their online special education teaching practice. These findings are similar to those reported by Anderson et al. (2017), who found that a sample of special education PSTs mainly drew upon their TPK (and overall TPACK) when making instructional decisions. Similarly, Anderson and Putnam (2020) found a significant amount of qualitative evidence for the application of eight SETs' TPK in their technology integration practices.

In the current study, a moderate amount of evidence was found indicating the application of participants' TK, TCK and TPCK in their professional practice, while no clear evidence was found for the direct application of participants' CK in their online special education teaching practice. This finding is consistent with previous researchers' work suggesting that special education teacher practice may rely less on CK (e.g., knowledge of content area curriculum standards) than does general education teaching practice (Maccini & Gagcon, 2002; Ruppar et al., 2017).

It is somewhat intuitive that general education teachers (especially at the secondary level) should possess greater CK than SETs, given that they are primarily responsible for teaching specific content area courses. SETs on the other hand, are primarily responsible for developing and implementing individualized instruction, accommodations and service plans that allow SWDs to obtain a meaningful benefit from their education, and to access the general education curriculum. Although SETs often do deliver content area instruction in co-taught classrooms, self-contained classrooms, and/or resource room ("pullout") models, they are often more focused on the implementation of evidence-based pedagogical practices (e.g., explicit instruction, strategy instruction), and the use of scaffolds and supports, which may be helpful to students across content areas (e.g., assistive technologies, classroom accommodations). This provides one possible explanation for the current study's relative lack of qualitative evidence for participants' application of CK (and other TPACK factors built upon CK) in their online teaching practice. Similarly, this may help to explain the abundance of evidence for the application of participants' TPK, given that they are striving to implement specific pedagogical strategies to support their students in a technology-rich, online learning environment.

Applied TPACK and HLP Implementation

Participants' collective qualitative responses showed evidence of both their applied TPACK and how participant TPACK facilitated the implementation of various HLPs in participants' online special education teaching practice. In order to determine the extent to which a particular TPACK factor informed the implementation of a given HLP, a coding matrix query was used to find out how many items (coherent chunks of qualitative data) were labeled with both a specific a priori code (TPACK factor) and HLP.

Participants' implementation of HLP 19 ("use assistive and instructional technologies") had the most qualitative evidentiary support of any HLP (93 items were labeled with this HLP). The implementation of HLP 19 was found to be informed predominantly by participants' TPK (105 items), but also by their TCK (30 items), TK (18 items), and TPCK (16 items).

The implementation of HLP 4 ("use multiple sources of information to develop a comprehensive understanding of a student's strengths and needs) was also found to be supported by a large amount of qualitative evidence (55 items were coded to HLP 4).

Participants' implementation of HLP 4 was found to be informed primarily by their applied TPK (22 items) and PK (22 items), in addition to their PCK (6 items), TK (4 items), and TPCK (4 items).

Participants' implementation of HLP 1 ("collaborate with professionals to increase student success") was supported by a significant amount of qualitative evidence (31 items coded to HLP 1). The implementation of HLP 1 was primarily informed by participants' TPK (17 items), in addition to PK (7 items), and to a much lesser extent by participant TK (1 item).

A significant amount of qualitative evidence (27 items) suggested participants' implementation of HLP 7 ("establish a consistent, organized, and respectful learning environment"). The implementation of HLP 7 was found to be informed by participants PK (10 items) and TPK (9 items).

Similarly, participants' implementation of HLP 3 ("collaborate with families to support student learning and secure needed services") was found to be supported by a significant amount of qualitative evidence (23 items coded to HLP 3). The implementation of HLP 3 was found to be informed mainly by participants' applied TPK (13 items), and also by their PK (5 items).

Participants' implementation of HLP 17 ("use flexible grouping") was also supported by a significant amount of qualitative evidence (22 items coded to HLP 17). Participants were found to primarily draw upon their TPK (11 items) and PK (8 items), and to a minor extent their TPCK (2 items), in their implementation of HLP 17.

The implementation of HLP 18 ("use strategies to promote student engagement") was also supported by a significant amount of qualitative evidence (21 items coded to

HLP 18). It was found that participants' implementation of HLP 18 was mainly informed by their PK (10 items), and also by their TPK (7 items).

A moderately large amount of qualitative data (18 items) was found for participants' implementation of HLP 9 ("teach social behaviors"). The qualitative evidence suggested that participants' implementation of HLP 9 was largely informed by their PK (12 items).

Similarly, participants' implementation of HLP 6 ("use student assessment data, analyze instructional practices, and make necessary adjustments that improve student outcomes") was also supported by a moderately large amount of qualitative evidence (16 items coded to HLP 6). The implementation of HLP 6 seemed to be informed primarily by participants' applied PK (7 items). A small number of participants' responses provided evidence that their implementation of HLP 6 was informed by their TPK (2 items), PCK (1 item), and TPCK (1 item).

A moderate amount of qualitative evidence (15 items) indicated participants' implementation of HLP 15 ("provide scaffolded supports"). Participants' implementation of HLP 15 was informed mainly by their applied PK (9 items), and to a lesser extent by their TPCK (3 items), TPK (2 items), and PCK (1 item).

Similarly, participants' implementation of HLP 12 ("identify and prioritize long- and short-term learning goals") was supported by a moderate amount of qualitative evidence (13 items). Participants were found to largely draw upon their PK (7 items) when implementing HLP 12. A small amount of evidence suggested that some participants also drew upon their TPCK (3 items), TPK (2 items), and PCK (1 item) when implementing HLP 12.

Participants' implementation of HLP 13 ("adapt curriculum tasks and materials for specific learning goals") was supported by a small to moderate amount of qualitative evidence (9 items). The implementation of HLP 13 was found to be informed primarily by participants' TPK (5 items), and to a lesser extent by their PK (3 items).

The implementation of HLP 8 was also indicated by a small to moderate amount of qualitative data (8 items). Participants' implementation of HLP 8 was found to draw upon their TPK (3 items) and PK (3 items).

Similarly, a small to moderate amount of qualitative evidence was found to indicate participants' implementation of HLP 2 ("organize and facilitate effective meetings with professionals"). Participants' implementation of HLP 2 was found to largely be informed by their TPK (4 items), and to a small extent by participant TK (1 item).

A small amount of qualitative evidence (5 items) suggested participants' implementation of HLP 22 ("provide positive and constructive feedback to guide students' learning and behavior"). The implementation of HLP 22 was found to be informed somewhat by participant PK (3 items), TPK (1 item), and PCK (1 item).

Participants' implementation of HLP 20 ("provide intensive instruction") was supported by a small amount of qualitative evidence. The qualitative data suggested that participants drew upon their TPK (2 items) and PK (2 items) in order to implement HLP 20.

Similarly, participants' implementation of HLP 14 ("teach cognitive and metacognitive strategies to support learning and independence") was supported by a small amount of qualitative evidence (4 items). It was found that participants' implementation of HLP 14 was somewhat informed by their PCK (2 items) and PK (2 items).

Only a small amount of qualitative evidence (3 items) was found indicating participants' implementation of HLP 16 ("use explicit instruction"). Participants' implementation of HLP 16 was found to be informed by their PK (1 item), and TPCK (1 item).

A similarly small amount of qualitative evidence (3 items) suggested participants' implementation of HLP 11 ("identify and prioritize long- and short-term learning goals"). The implementation of HLP 11 was found to be informed by participant PK (1 item) and TPCK (1 item).

A very small amount of qualitative data was found that indicated participants' implementation of HLP 21 ("teach students to maintain and generalize new learning across time and settings"). However, none of the items coded to HLP 21 were also coded as evidence of the application of a specific TPACK factor, which could suggest that participants' implementation of HLP 21 may be informed by knowledge factors not fully captured by the TPACK framework (e.g., knowledge of students).

Only one participant's qualitative responses showed evidence for the implementation of HLP 5 ("interpret and communicate assessment information with stakeholders to collaboratively design and implement educational programs"), which was found to be informed by the participants' applied TPK (1 item).

Zero qualitative items were found suggesting participants' implementation of HLP 10 ("conduct functional behavioral assessments to develop individual student behavior support plans").

Lastly, it was found that participants applied their TPK and PK to address (and attempt to ameliorate) persistent challenges related to their online special education teaching practice. In particular, participants addressed challenges related to student engagement through the implementation of HLP 18 ("using strategies to promote student engagement"). These strategies included the provision of student choice within lessons, and the application of UDL principles to create engaging instruction at students' individual performance levels (evidence of PK), as well as the use of interactive digital presentations, digital learning games, fun digital elements (such as emojis), and the use of video conferencing platforms to facilitate peer-to-peer interactions and collaborate with families on strategies to promote student engagement (evidence of TPK).

Participants also applied their PK to address challenges related to the development of students' social and behavioral skills in online school. This was found to occur mainly through participants' implementation of HLP 9 ("teach social behaviors"). More specifically, participants reported teaching social skills through the use of social stories and scenario-based instruction, implementing commercially available SEL curricular programs with students, teaching coping strategies, and modeling positive behaviors for students.

<u>Mixed-Methods Findings and Discussion</u>

Both the quantitative and qualitative data were combined and analyzed in NVivo QDAS in order the answer the following research question:

> How do the quantitative and qualitative findings related to participants' TPACK converge and/or diverge?

Convergent Findings

The mixed methods analysis yielded two convergent findings and two divergent findings. Firstly, a convergence was found in that both the quantitative and qualitative data suggested that increased participant age may be associated with decreased self-assessed TK. The multiple regression analysis revealed that participant age significantly predicted mean TK scores, while the qualitative data also included discussions from two older participants (between 61 and 71 years old) referencing challenges in their practice related to technological knowledge and skill. This convergent result provides additional evidence for the assertion that teacher age (in this specific case, online SET age) may be negatively correlated with teacher TK (and perhaps other technology related TPACK factors). As previously discussed, this finding is consistent with prior research demonstrating an inverse relationship between teacher age and technology related TPACK factors, including TK (Kazu & Erten, 2014; Koh et al., 2014a; Piret et al., 2018). However, it remains unclear whether this observed relationship is truly a function of teacher age, or perhaps could be better explained by the generation to which a teacher belongs. In other words, it may be that teachers who grew up before personal computing devices were widely accessible (e.g., prior to 1980) tend to have deficits (or at least a lack of confidence) with respect to their TK, compared to teachers who have grown up surrounded by ubiquitous digital tools.

A second convergence related to estimations of participant PK. Participants' responses to the TPACK.xs survey showed that they rated themselves higher in PK (M = 4.37; SD = 0.66) than any other TPACK factor. Similarly, qualitative data analysis found a large amount of evidence for the application of participants' PK in their online special education teaching practice, including with respect to the implementation of HLPs. This finding partially contrasts with previous research reporting that SETs were rated highest in the factors of TK (Cahyani & Evans, 2021), TK and TPK (Anderson & Putnam, 2020), or PCK (Ramkrishnan et al., 2020), it is consistent with the common sense understanding that SpecEd as a field is largely concerned with the application of effective pedagogical strategies (relative to issues related more directly to content, or technology).

Divergent Findings

The mixed methods analysis produced two main divergent findings. Firstly, the quantitative data (results from the TPACK.xs survey) showed that participants rated themselves lowest, on average, in TPK (despite still self-reporting moderately high mean TPK scores overall). However, analysis of participants' qualitative reports suggested that TPK may be the TPACK factor most often applied in participants' online special education teaching practice, especially with respect to their implementation of HLPs. As has been mentioned previously, the qualitative finding that SETs may rely heavily on their TPK when making decisions related to the use of instructional technologies is consistent with prior research findings by Anderson et al. (2017). Therefore, it seems somewhat inconsistent that this sample of online SETs should rate themselves lower in TPK than any other TPACK factor.

One possible explanation for this finding is that applications of TPK may be so prevalent in online SETs' professional practice that they are more aware of their own deficiencies with respect to TPK, compared to other TPACK factors. A related possible and partial explanation is that some participants' results may be impacted by a Dunning-Kruger effect, whereby they overestimate their own knowledge and ability, simply because of their lack of experience in a given domain (Kruger & Dunning, 2009). For example, if participants are lacking somewhat in actual CK, they may mistakenly overestimate their own knowledge. However, because online SETs do in fact have a significant amount of experience applying their TPK in practice (as their instructional decision making relies heavily on this factor), they may have a more accurate, and therefore lower, estimation of their knowledge in this domain.

A second divergent finding was observed with respect to estimations of participants' CK. While participant responses to the TPACK.xs survey showed relatively high mean scores for the CK factor ($M = 4.22$), qualitative data analysis yielded no direct evidence for participants' application of CK in their online teaching practice. Rather, it was found that participants' CK could be inferred from qualitative data suggesting the application of a component factor built upon CK (TCK, PCK, or TPCK). As has been mentioned previously, there is reason to suspect that SETs may generally rely more on PK than CK in their professional work. Therefore, it is somewhat expected to find little evidence of applied CK in the participants' qualitative responses. However, it is somewhat surprising to also find that participants' self-reported CK was quite high.

One possible explanation for this second divergent finding is simply that participants accurately self-assessed their CK, but due to the nature of their jobs, they only seldom need to directly apply their CK in practice (and therefore evidence of CK was not found in their qualitative responses). SETs are often tasked with providing remedial or supplemental instruction and/or instructional supports, rather than the provision of core content area instruction. Even when SETs are responsible for core content area instruction, they are often working in tandem with a general education teacher (as in a co-teaching model) who is considered the content expert (Friend, 2007), or are delivering modified content area instruction, which may require the application of less specialized CK than typical general education teaching.

As mentioned above, the impact of the Dunning-Kruger effect could also partially explain the divergent findings related to participant CK. To briefly reiterate this explanation, it is possible that participants' actual lack of CK could lead to overestimations of their CK. This seems possible, as SET preparation programs may not require PSTs to take higher level content area courses (e.g., advanced mathematics, language arts or science courses), as would be expected in general education teacher preparation programs (Maccini & Gagnon, 2006).

Implications

The first convergent finding, consistent with several prior researchers' findings (Kazu & Erten, 2014; Koh et al., 2014a; Piret et al., 2018) that participant age (or as was previously suggested, teacher generation) may be negatively correlated with TK suggests that when asking SETs to integrate technology into their instruction, schools should have extra supports available for their older teachers (or any teachers who did not grow up surrounded by personal digital technologies). It is recommended that both basic and ongoing training and professional development related to the use of essential job-related technologies be made available to SETs. This could help improve the job-related TK of teachers who may have deficits or gaps of knowledge in this area.

The divergent finding that participants rated themselves highly on CK, while qualitative responses showed scant evidence of applied CK, suggests that online SETs may tend to overestimate their actual CK. Although for SETs, CK is perhaps not as essential to their teaching practice as it might be for general education teachers, it is nonetheless an important knowledge domain that impacts instructional decision making. Therefore, special education teacher preparation programs should consider using strategies to further build PSTs' CK, especially in the core academic areas of language arts and mathematics. For example, these programs could consider requiring additional content specific elective courses for graduation. Additionally, K-12 schools should consider making more content specific professional development offerings available to SETs to build their CK.

The large amount of qualitative evidence suggesting the critical importance of participants' applied TPK in their practice and implementation of HLPs suggests that TPK may be an area of strength for online SETs, despite the fact that participants rated themselves higher in other knowledge areas assessed with the TPACK.xs. Additionally, the second convergent finding suggests that PK may also be a critically important factor impacting the teaching practice of online SETs. Online K-12 schools should consider leveraging these potential strengths by allowing their SETs to play a greater role in decision making processes related to (1) the selection of technological tools and apps used to develop and deliver instructional materials and assessments for SWDs, and (2) the ways in which these technologies are implemented in order to best meet the individual needs of SWDs.

Participants' qualitative responses provided evidence for how this sample of online SETs implemented a number of HLPs in their practice. This is an encouraging finding, especially given that the HLPs were not specifically designed for implementation in online learning contexts. While it is clear that this sample of online SETs applied their

TPACK in various ways to assess student performance, design and deliver instruction, collaborate with colleagues and families, and promote students' social-emotional and behavioral growth in online schools, the relative lack of qualitative evidence found for the implementation of several important HLPs suggests there may be room for improvement in this area. Especially concerning is the lack of evidence found for the implementation of HLP 16 ("use explicit instruction"), which is a central EBP recommended for use with SWDs (Johnson et al., 2019; Riccomini et al., 2016). Also concerning was the lack of evidence for participants' implementation of HLP 10 ("conduct functional behavioral assessments to develop individual student behavior support plans"), which is not only a "best practice", but also a practice that is legally mandated in certain contexts (IDEA, 2004). Additionally, only a small amount of qualitative evidence was found indicating participants' implementation of HLP 20 ("provide intensive instruction"), HLP 14 ("teach cognitive and metacognitive strategies to support learning and independence"), and HLP 11 ("identify and prioritize long- and short-term learning goals"). While the lack of qualitative evidence among participant responses certainly does not indicate that these HLPs are absent from online SET practice, it does suggest that online SETs may want to be more intentional about their implementation of HLPs, especially those that are of central importance from an instructional standpoint (explicit instruction), as well as in terms of legal compliance (use of functional behavioral assessments in the development of behavior intervention plans). Similarly, teacher preparation programs and K-12 schools should work to develop special education PST's and ISTs' knowledge of the HLPs, including clear examples of how these might be implemented in both brick and mortar, and online contexts.

A final implication of this study's findings relates to participants' knowledge of students (including knowledge of students' individual strengths, preferences, interests, homelife, background, and future aspirations) which emerged as an important domain of knowledge impacting teacher practice and the implementation of HLPs, but was not entirely captured by, or explainable with reference to, the TPACK factors. It may be beneficial for future researchers hoping to apply the TPACK framework in special education contexts to explicitly include this knowledge domain in their analysis.

Recommendations for Future Research

The findings from this study suggest several possible fruitful avenues of exploration for future research projects. Firstly, it is recommended that future research look more closely at the relationship between teacher age and technology related TPACK factors, while controlling for teacher generation. It would be useful to know if decreases in technology related knowledge can be expected as teachers age (and if so, at what age the beginning of this decline can be expected), or whether this relationship might better be explained by an appeal to Prensky's (2001) concept of digital natives (born after approximately 1980) as compared to digital immigrants (born before approximately 1980). If a negative correlation between age and TPACK was observed even controlling for teacher generation, it might then be prudent to investigate the effectiveness of interventions designed to improve and/or maintain the TPACK of teachers as they age.

Similarly, future research should investigate the effectiveness of interventions generally designed to improve the TPACK of SETs (both those working in brick-and-mortar settings, and those working in online learning contexts). Perhaps especially useful would be research into interventions (e.g., professional development offerings, courses of study within teacher preparation programs) designed to improve SET CK.

Additionally, it is recommended that future studies utilizing the TPACK framework in special education and/or online learning contexts make use of performance and/or observational instruments to measure teacher TPACK. This would help to overcome the limitations inherent in the use of self-report measures, including questionable reliability due to the possible impact of the Dunning-Kruger effect, or other factors.

Qualitative research seeking to analyze and describe the teaching practices and methods of online SETs identified as exceptional or highly effective (e.g., award winning SETs, or those nominated by an administrator) would also be helpful in order to identify promising practices in this growing field.

Finally, and perhaps most urgently, it is recommended that future research seek to determine the impact of teacher TPACK (as measured by self-report surveys, performance measures, observational assessments, or other instruments) on student outcomes (e.g., grades, standardized test scores), in both general and special education, and in brick and mortar as well as online learning contexts. For the purposes of this study, an assumption was made that higher levels of teacher TPACK lead to the implementation of more effective teaching practices (defined in terms of positive impacts on student achievement). However, additional research is needed to either confirm or disconfirm this assumption, which would then help researchers better evaluate the fruitfulness of research projects seeking to measure or quantify teacher TPACK.

Limitations

This study has several clear limitations. Firstly, the relatively small sample size (*N* = 46) limits the generalizability of findings. Generalizability is also limited as the sample included only secondary online SETs working in public and/or charter schools in the United States. Furthermore, the sampling method, which relied partially on a snowball effect, and may have been limited due to selection bias (e.g., participants with higher levels of technology related knowledge and skill may be overrepresented among the sample), also limits the generalizability of findings. Additionally, the use of a convergent mixed methods research design, while perhaps offsetting the flaws inherent in either a pure quantitative or qualitative design, may have sacrificed some of the generalizability and reliability of a purely quantitative approach, as well as the potential depth and detail of a purely qualitative approach. The reliability of findings are somewhat limited due to the fact that only one researcher engaged in coding and qualitative data analysis. Another potential limitation relates to the relatively low percentage of variance explained by some of the multiple regression predictive models, which could be explained by the relatively low variance in participants' TPACK survey responses (0.2025 on a 5-point scale), and perhaps by the non-inclusion of certain important predictor variables from these models. Finally, the use of qualitative data analysis techniques to characterize participants' applied TPACK and the implementation of HLPs in their online teaching practice was somewhat experimental, and more prone to the impact of researcher bias and/or subjectivity than other more objective measures might have been.

Significant Contributions of the Study

Several findings of this study extended findings from previous research to the context of K-12 online special education teaching. For example, previous researchers have observed a significant negative relationship between teacher age and TK (Kazu & Erten, 2014; Koh et al., 2014a; Piret et al., 2018). However, the researcher is not aware of any previous study which replicated this finding in the context of K-12 online special education, or which provided both quantitative and qualitative support for this finding, as was done in the current study. Additionally, while previous research has suggested the relative importance of special education teachers' TPK and PK in their professional practice (Anderson et al., 2017; Anderson & Putnam, 2020) the current study extends this finding into the context of online special education practice.

The current study also provides a glimpse into how online special education teachers are implementing HLPs in their practice, which has not been a major focus of previous research efforts. Furthermore, the current study has demonstrated that the TPACK.xs (Schmid et al., 2019) survey instrument can be used to reliably capture online special education teachers' self-reported TPACK. This instrument has several advantages to the more frequently used SPTKTT (Schmidt et al., 2009) instrument, in that it was developed more recently, and is neutral with respect to teacher content area.

Conclusion

This convergent design-mixed methods study sought to explore the self-reported and applied TPACK of a sample of secondary online SETs (N = 46), meaning those SETs working at online public and/or charter schools in the United States. Both the quantitative and qualitative data were collected via the administration of an online survey form consisting of a demographic survey component, the TPACK.xs survey (Schmid et al., 2020), and a 10-item qualitative questionnaire developed by the researcher to solicit information related to the application of online SET TPACK and the implementation of HLPs within their online teaching practice.

Standard multiple regression analyses were used to find models that significantly predicted participant TPACK (and individual TPACK factors) from the predictor variables of participant age, online teaching experience, educational level, and certification status, mean TK, mean PK, and mean CK. Five significant models were identified, with the criterion variables of (1) mean TPCK, (2) mean TPK, (3) mean TCK, (4) mean PCK, and (5) mean TK.

The qualitative data were coded for evidence of participant TPACK using the seven standard TPACK factors (TK, PK, CK, TPK, TCK, PCK, TPCK) as a priori codes. Additional rounds of descriptive and pattern coding were also used, and the qualitative data were coded for evidence of participants' implementation of specific HLPs. The qualitative data analysis suggested that participants' online teaching practice was informed most heavily by their applied TPK, and also significantly by their applied PK. Participants' online teaching practice was found to be partially informed by their applied TK, PCK, TCK, and TPCK. However, no direct evidence for the application of participant CK was found in the qualitative data, suggesting that CK may represent a relative deficit area for this sample of online SETs.

Qualitative data analysis also provided evidence that participants drew upon their applied TPACK (again, mainly TPK and PK) in order to implement 21 out of 22 HLPs in their online teaching practice. However, only a small amount of qualitative evidence indicated participants' implementation of several critically important HLPs. Perhaps most notably, only a few participants' qualitative responses provided evidence for their use of a central component of highly effective special education teaching practice, explicit instructional techniques (HLP 16). Additionally, no qualitative evidence was found for any participants' use of functional behavioral assessments and/or behavior support plans (HLP 10) despite this practice being legally mandated when student behaviors are determined to significantly interfere with learning.

After the qualitative and quantitative data were analyzed separately, both data sets were combined and analyzed concurrently to identify convergences and/or divergences. The mixed-methods analysis yielded two convergent findings. Qualitative responses from two participants above the age of 61 suggested deficits and/or challenges in their practice related to their applied TK, while no similar qualitative data related to technological challenges were located among teachers aged 31-60. These qualitative data points were found to be supportive of the quantitative finding that participant age was significantly and negatively correlated with participant TK and TPCK. It is hypothesized, however, that this finding might better be explained with reference to teacher generation (for which age is merely a proxy). A second convergence was found relating to quantitative and qualitative assessments of participants' PK, which in both instances was found to be high, suggesting that PK may be a critical factor impacting the practice of online SETs.

The mixed-methods analysis also resulted in the identification of two divergent findings. The first divergence was related to an asymmetry observed between the quantitative and qualitative data indicative of participants' TPK. The qualitative data was found to provide more evidence of the application of participants' TPK than any other

TPACK factor, while the quantitative data showed that participants self-reported lower mean TPK than any other TPACK factor. It is hypothesized that participants' may be more acutely aware of their deficits and/or challenges related to the application of their TPK (compared with other TPACK factors) precisely because they rely so much on this knowledge domain in their teaching practice.

A second divergent finding related to an asymmetry observed between the quantitative and qualitative data indicative of participants' CK. While the qualitative data was found to provide no direct evidence for applications of CK in participants' online teaching practice, the quantitative data indicated that participants self-reported relatively high CK. One possible explanation is that a Dunning-Kruger like effect may have led to participants overestimating their CK. This is conceivable given that SET preparation and training often emphasizes pedagogy over content (Maccini & Gagnon, 2006). Another possible explanation is that participants' may not find it necessary to directly apply CK in their online special education teaching practice, but that their CK can be inferred through applications of TCK, PCK and TPCK.

The current study extended previous findings related to teacher age and TK, and the relative importance of SET TPK and PK, to the context of K-12 online special education. Additionally, the study provided some detailed information related to SET's implementation of HLPs in their online teaching practice, while demonstrating that TPACK framework and TPACK.xs survey can be used effectively to characterize the self-reported knowledge and teaching practices of K-12 online SETs. The use of the mixed-methods techniques enhanced the overall validity of the research findings, especially with respect to identified areas of convergence, and offset the limitations inherent in both quantitative and qualitative methods.

References

Abbitt, J. T. (2011). Measuring technological pedagogical content knowledge in preservice teacher education: A review of current methods and instruments. *Journal of Research on Technology in Education, 43*(4), 281-300. https://doi.org/10.1080/15391523.2011.10782573

Açıkgül, K. & Aslaner, R. (2019). Investigation relations between the technological pedagogical content knowledge efficacy levels and self-efficacy perception levels of pre-service mathematics teachers. *Çukurova University Faculty of Education Journal, 48*(1), 1-31. DOI: 10.14812/cufej.409949

Ahlam-Mohammed, A. A. (2019). Auditing the TPACK confidence of pre-service teachers: The case of Saudi Arabia. *Education and Information Technologies, 24*(6), 3393-3413. https://doi.org/10.1007/s10639-019-09924-0

Akman, O. & Guven, C. (2015). TPACK survey development study for social sciences teachers and teacher candidates. *International Journal of Research in Education and Science, 1*(1), 1-10. https://files.eric.ed.gov/fulltext/ED548292.pdf

Akturk, A. O. & Saka-Ozturk, H. (2019). Teachers' TPACK levels and students' self-efficacy as predictors of students' academic achievement. *International Journal of Research in Education and Science, 5*(1), 283-294. https://files.eric.ed.gov/fulltext/EJ1197990.pdf

Akyuz, D. (2018). Measuring technological pedagogical content knowledge (TPACK) through performance assessment. *Computers & Education, 125*, 212-225. https://doi.org/10.1016/j.compedu.2018.06.012

Alawadh, A. S, Ali, N. G. H., Almutairi, F. M., & Alhuzimi, T. E. (2019). Pre-service teachers' perceptions of their abilities to teach students with special needs by integration technology in their classrooms. *Journal of Education and Practice, 10*(35), 84-92. https://doi.org/10.7176/JEP/10-35-12

Allday, C. M., & Allday, R. A. (2011). Effects of pacing options on final grades of students with disabilities in virtual high school. *The Quarterly Review of Distance Education, 12*(4), 223-234.

Allen, D., Carpenter, L. B., & Wright, J. V. (2009). Assistive technology: What every school leader should know. *Education, 129*(3), 556-560. https://eric.ed.gov/?id=EJ871601

Ames, K., Harris, L. R., Dargusch, J., & Bloomfield, C. (2021). 'So you can make it fast or make it up': K–12 teachers' perspectives on technology's affordances and constraints when supporting distance education learning. *Australian Educational Researcher, 48*(2), 359-376. https://doi.org/10.1007/s13384-020-00395-8

An, Y., Kaplan-Rakowski, R., Yang, J., Conan, J., Kinard, W., & Daughrity, L. (2021). Examining K-12 teachers' feelings, experiences, and perspectives regarding online teaching during the early stage of the COVID-19 pandemic. *Educational Technology Research & Development, 69*(5), 2589-2613. https://doi.org/10.1007/s11423-021-10008-5

Anderson, S., Griffith, R., & Crawford, L. (2017). TPACK in SpecEd: preservice teacher decision making while integrating iPads into instruction. *Contemporary Issues in Technology and Teacher Education, 17*(1), 97-127.

https://citejournal.org/volume-17/issue-1-17/general/tpack-in-special-education-preservice-teacher-decision-making-while-integrating-ipads-into-instruction/

Anderson, S. E. & Putman, R. S. (2020). Special education teachers' experience, confidence, beliefs, and knowledge about integrating technology. *Journal of SpecEd Technology, 35*(1), 37-50. https://doi.org/10.1177/0162643419836409

Archambault, L., & Crippen, K. (2009). Examining TPACK among K-12 distance educators in the United States. *Contemporary Issues in Technology and Teacher Education, 9*(1), 71-88. https://citejournal.org/wp-content/uploads/2016/04/v9i1general2.pdf

Archambault, L., Kennedy, K., & Bender, S. (2013). Cyber-truancy: Addressing issues of attendance in the digital age. *Journal of Research on Technology in Education, 46*(1), 1-28. https://doi.org/10.1080/15391523.2013.10782611

Arnesen, K. T., Hveem, J., Short, C. R., West, R. E., & Barbour, M. K. (2019). K-12 online learning journal articles: trends from two decades of scholarship. *Distance education, 40*(1), 32-53. https://doi.org/10.1080/01587919.2018.1553566

Ay, Y., Karadağ, E., & Acat, M. B. (2015). The Technological Pedagogical Content Knowledge-practical (TPACK-Practical) model: Examination of its validity in the Turkish culture via structural equation modeling. *Computers & Education, 88*, 97-108. https://doi.org/10.1016/j.compedu.2015.04.017

Baier, F. & Hunter, M. (2020). Construction and validation of a test to assess (pre-service) teachers' technological pedagogical knowledge (TPK). *Studies in Educational Evaluation, 67*, 1-11. https://doi.org/10.1016/j.stueduc.2020.100936

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*(2), 191–215. https://doi.org/10.1037/0033-295X.84.2.191

Baran, E., Bilici, S. C., Sari, A. A., & Tondeur, J. (2019). Investigating the impact of teacher education strategies on preservice teachers' TPACK. *British Journal of Educational Technology, 50*(1), 357-370. https://doi.org/10.1111/bjet.12565

Barbour, M., Siko, J. P., & Simuel-Everage, K. (2013). Pictures from an Exhibition... of Online Learning: A Creative Representation of Qualitative Data. *Qualitative Report, 18*(23), 1-15.

Barbour, M. K. (2021). The Shift to Distance Learning: Tracing the Roots of 100+ Years of Practice and Opportunity. *TechTrends, 65*(6), 919-922. https://doi.org/10.1007/s11528-021-00670-0

Barbour, M. K. (2022). Where do they go? An investigation of K-12 online learners process for obtaining support. *TechTrends, 66,* 351-365. https://doi.org/10.1007/s11528-022-00698-w

Basham, J. D., Carter, R. A., Rice, M. F., & Ortiz, K. (2016). Emerging state policy in online SpecEd. *Journal of SpecEd Leadership, 29*(2), 70-78.

Basham, J. D., Smith, S. J., Greer, D. L., & Marino, M. T. (2013). The scaled arrival of K-12 online education: Emerging realities and implications for the future of education. *Journal of Education, 193*(2), 51-59. https://doi.org/10.1177/002205741319300206

Beasley, J. G., & Beck, D. F. (2017). Defining differentiation in cyber schools: What online teachers say. *TechTrends, 61*, 550-559. https://doi.org/10.1007/s11528-017-0189-x

Beck, D., Egalite, A., & Maranto, R. (2014). Why they choose and how it goes: Comparing SpecEd and general education cyber student perceptions. *Computers & Education, 76,* 70-79. https://doi.org/10.1016/j.compedu.2014.03.011

Bingimlas, K. (2018). Investigating the level of teachers' knowledge in technology, pedagogy, and content (TPACK) in Saudi Arabia. *South African Journal of Education, 38*(3), 1-12.

Birks, M., Chapman, Y., & Francis, K. (2008). Memoing in qualitative research: Probing data and processes. *Journal of Research in Nursing, 13*(1), 68–75. https://doi.org/10.1177/1744987107081254

Blau, I., Peled, Y., & Nusan, A. (2016). Technological, pedagogical and content knowledge in one-to-one classroom: teachers developing "digital wisdom". *Interactive Learning Environments, 24*(6), 1215-1230. https://doi.org/10.1080/10494820.2014.978792

Blonder, R. & Rap, S. (2017). "I like Facebook: Exploring Israeli high school chemistry teachers' TPACK and self-efficacy beliefs." *Education and Information Technologies, 22*(2), 697-724. https://doi.org/10.1007/s10639-015-9384-6

Borup, J. (2016a). Teacher perceptions of learner-learner engagement at a cyber high school. The *International Review of Research in Open and Distributed Learning, 17*, 231-250. https://doi.org/10.19173/IRRODL.V17I3.2361

Borup, J. (2016b). Teacher perceptions of parent engagement at a cyber high school. *Journal of Research on Technology in Education, 48*(2), 67-83. doi:10.1080/15391523.2016.1146560

Borup, J., & Stevens, M. A. (2017). Using student voice to examine teacher practices at a cyber charter high school. *British Journal of Educational Technology, 48*(5), 1119-1130. https://doi.org/10.1111/bjet.12541

Borup, J., Graham, C. R., & Davies, R. S. (2013). The nature of parental interactions in an online charter school. *American Journal of Distance Education, 27*(1), 40-55. https://doi.org/10.1080/08923647.2013.754271

Borup, J., Graham, C. R., & Davies, R. S. (2014a). The nature of adolescent learner interaction in a virtual high school setting. *Journal of Computer Assisted Learning, 29*(2), 153-167. https://doi.org/10.1111/j.1365-2729.2012.00479.x

Borup, J., Graham, C. R., & Drysdale, J. S. (2014b). The nature of teacher engagement at an online high school. *British Journal of Educational Technology, 45*(5), 793-806. https://doi.org/10.1111/bjet.12089

Bostancıoğlu, A. & Handley, Z. (2018). Developing and validating a questionnaire for evaluating the EFL 'Total PACKage': Technological pedagogical content knowledge (TPACK) for English as a foreign language (EFL). *Computer Assisted Language Learning, 31*(5-6), 572-598. https://doi.org/10.1080/09588221.2017.1422524

Bozkurt, E. (2014). TPACK levels of physics and science teacher candidates: Problems and possible solutions. *Asia-Pacific Forum on Science Learning and Teaching, 15*(2), 1-22.

Brantley-Dias, L. & Ertmer, P. A. (2013). Goldilocks and TPACK: Is the construct "just right"? *Journal of Research on Technology in Education, 46*(2), 103-128. https://doi.org/10.1080/15391523.2013.10782615

Cahyani, L. A., Aziza, N. & Evans, D. (2021). Technological pedagogical and content knowledge (TPACK) of special education teachers in science instruction for students with special needs. *Formatif: Jurnal Ilmiah Pendidikan MIPA, 11*(1), 103-112.

Çalik, M., Özsevgeç, T., Ebenezer, J., Artun, H., & Küçük, Z. (2014). Effects of 'environmental chemistry' elective course via technology-embedded scientific inquiry model on some variables. *Journal of Science Education and Technology, 23*(3), 412-430. https://doi.org/10.1007/s10956-013-9473-5

Carnahan, C., & Fulton, L. (2013). Virtually forgotten: SpecEd students in cyber schools. *TechTrends, 57*(4), 46-52.

Cavanagh, R. F., & Koehler, M. J. (2013). A Turn toward specifying validity criteria in the measurement of Technological Pedagogical Content Knowledge (TPACK). *Journal of Research on Technology in Education, 46*(2), 129-148

Chai, C. S., Koh, J. H. L., Tsai, C. C., & Tan, L. L. W. (2011). Modeling primary school pre-service teachers' Technological Pedagogical Content Knowledge (TPACK) for meaningful learning with information and communication technology (ICT). *Computers and Education, 57*, 1184-1193.

Champa, T., Waterbury, T., & McQuinn, A. (2020). Utilizing the pandemic disruption to identify distance learning challenges. *Quarterly Review of Distance Education, 21*(4), 51-63.

Chen, H. Y., & Jang, S. J. (2013). Exploring the reasons for using electric books and technological pedagogical and content knowledge of Taiwanese elementary mathematics and science teachers. *TOJET: The Turkish Online Journal of Educational Technology, 12*(2), 131-141. https://files.eric.ed.gov/fulltext/EJ1015403.pdf

Chenail, R. J. (2012). Conducting qualitative data analysis: Reading line-by-line, but analyzing by meaningful qualitative units. *Qualitative Report, 17*(1), 266–269. https://nsuworks.nova.edu/tqr/vol17/iss1/12/

Cheung, Y. L., & Jang, H. (2020). Understanding writing teachers' technological pedagogical content knowledge: A study with five in-service teachers. *Indonesian Journal of Applied Linguistics, 10*(2), 551-561. https://doi.org/10.17509/ijal.v10i2.28607

Corry, M., & Stella, J. (2012). Developing a framework for research in online K-12 distance education. *Quarterly Review of Distance Education, 13*(3), 133-151.

Courduff, J., Szapkiw, A., & Wendt, J. L. (2016). Grounded in what works: Exemplary practice in special education teachers' technology integration. *Journal of SpecEd Technology, 31*(1), 26-38.

Coy, K. (2014). Special educators' roles as virtual teachers. *Teaching Exceptional Children, 46*(5), 110-116. https://doi.org/10.1177/0040059914530100

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Quantitative, qualitative, and mixed methods approaches* (5th ed.). Thousand Oaks, CA: SAGE Publications.

Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research* (3rd ed.). SAGE Publications.

Crouse, T., Rice, M., & Mellard, D. (2018). Learning to serve students with disabilities online: Teachers' perspectives. *Journal of Online Learning Research, 4*(2), 123-145. https://files.eric.ed.gov/fulltext/EJ1184994.pdf

Darling-Aduana, J. (2021). Authenticity, engagement, and performance in online high school courses: Insights from micro-interactional data. *Computers & Education, 167*. https://doi.org/10.1016/j.compedu.2021.104175

de la Varre, C., Irvin, M. J., Jordan, A. W., Hannum, W. H., & Farmer, T. W. (2014). Reasons for student dropout in an online course in a rural K–12 setting. *Distance education, 35*(3), 324-344. https://doi.org/10.1080/01587919.2015.955259

Demirok, M. S. & Baglama, B. (2018). Examining technological and pedagogical content knowledge of special education teachers based on various variables. *TEM Journal 7*(3), 507-512. https://doi.org/10.18421/TEM73-06

Dinçer, S. (2018). Are preservice teachers really literate enough to integrate technology in their classroom practice? Determining the technology literacy level of preservice teachers. *Education and Information Technologies, 23*(6), 2699-2718. https://doi.org/10.1007/s10639-018-9737-z

DiPietro, M., Ferdig, R.E., Black, E.W., & Preston, M. (2008). Best practices in teaching K-12 online: Lessons learned from Michigan virtual school teachers. *Journal of Interactive Online Learning, 7*(1), 10-35.

Dobi-Barišić, K., Divjak, B., & Kirinić, V. (2019). Education Systems as Contextual Factors in the Technological Pedagogical Content Knowledge Framework. *Journal of Information and Organizational Sciences, 43*(2), 163-183. https://doi.org/10.31341/jios.43.2.3

Dong, Y., Chai, C. S., Sang, G. Y., Koh, J. H. L., & Tsai, C. C. (2015). Exploring the profiles and interplays of pre-service and in-service teachers' technological pedagogical content knowledge (TPACK) in China. *Educational Technology & Society, 18*(1), 158-169. https://repository.nie.edu.sg/bitstream/10497/17325/1/ETS-18-1-158.pdf

Dong, Y., Xu, C., Chai, C. S., & Zhai, X., (2020). Exploring the structural relationship among teachers' technostress, technological pedagogical content knowledge (TPACK), computer self-efficacy and school support. *The Asia-Pacific Education Researcher, 29*(2), 147-157. https://doi.org/10.1007/s40299-019-00461-5

Ersoy, M., Yurdakul, I. K., & Ceylan, B. (2016). Investigating preservice teachers' TPACK competencies through the lenses of ICT skills: An experimental study. *Egitim ve Bilim, 41*(186), 119-135. https://doi.org/10.15390/eb.2016.6345

Eutsler, L. (2020). TPACK's pedagogy and the gradual release of responsibility model coalesce: integrating technology into literacy teacher preparation. *Journal of Research on Technology in Education*, 1-18. https://doi.org/10.1080/15391523.2020.1858463

Farrell, I. K. & Hamed, K. M. (2017). Examining the relationship between technological pedagogical content knowledge (TPACK) and student achievement utilizing the Florida value-added model. *Journal of Research on Technology in Education, 49*(3-4), 161-181. https://doi.org/10.1080/15391523.2017.1328992

Fernandez, H., Ferdig, R. E., Thompson, L. A., Schottke, K., & Black, E. W. (2016). Students with special health care needs in K-12 virtual schools. *Journal of Educational Technology & Society, 19*(1), 67-75.

Fiesler, C., & Proferes, N. (2018). "Participant" perceptions of Twitter research ethics. *Social Media + Society, 4(*1), 1-14. https://doi.org/10.1177/2056305118763366

Flores, S., Walters, N.M., & Kiekel, J. (2018). Academic instruction at a distance: An examination of holistic teacher perceptions at a virtual high school. *Online Journal of Distance Learning Administration, 21*(1). https://www.westga.edu/~distance/ojdla/spring211/flores_kiekel211.html

Ford, R., & Rice, K. (2015). Value-Added Results for Public Virtual Schools in California. *Journal of Educational Technology & Society, 18*(4), 412-423.

Fredricks, J. A., Blumenfield, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of evidence. *Review of Educational Research, 74*(1), 59-109. https://doi.org/10.3102%2F00346543074001059

Friend, M. (2007). The coteaching partnership. *Educational Leadership, 64*(5), 48-52.

Garrison, D. R., Anderson, T., & Archer, W. (2000). Critical inquiry in a text-based environment: Computer conferencing in higher education model. *The Internet and Higher Education, 2*(2-3), 87-105. https://doi.org/10.1016/S1096-7516(00)00016-6

Gill, B., Walsh, L., & Smither-Wulsin, C. (2015). Inside Online Charter Schools. *Mathematica Policy Research.* Cambridge, MA. https://mathematica.org/publications/inside-online-charter-schools

Gokdas, I. & Torun, F. (2017). Examining the impact of instructional technology and material design courses on technopedagogical education competency acquisition according to different variables. *Educational Sciences: Theory & Practice, 17*(5), 1733-1758. https://psycnet.apa.org/doi/10.12738/estp.2017.5.0322

Graham, C. R., Burgoyne, N., Cantrell, P., Smith, L., St. Clair, L., & Harris, R. (2009). TPACK development in science teaching: Measuring the TPACK confidence of inservice science teachers. *TechTrends, 53*(5), 70-79. https://doi.org/10.1007/s11528-009-0328-0

Gratz, T., Goldhaber, D., & Brown, N. (2022). The pre-pandemic growth in online public education and the factors that predict it. *Journal of School Choice.* https://doi.org/10.1080/15582159.2022.2098446

Greer, D., Rowland, A. L., & Smith, S. J. (2014). Critical considerations for teaching students with disabilities in online environments. *Teaching Exceptional Children, 46*(5), 79-91. https://doi.org/10.1177/0040059914528105

Habibi, A., Yusop, F. D., & Rasak, R. A. (2020). The role of TPACK in affecting pre-service language teachers' ICT integration during teaching practices: Indonesian context. *Education and Information Technologies, 25*(3), 1929-1949. https://doi.org/10.1007/s10639-019-10040-2

Hall, J. A., Lei, J., & Wang, Q. (2020). The first principles of instruction: an examination of their impact on preservice teachers' TPACK. *Educational Technology Research and Development, 68*(6), 3115-3142. https://doi.org/10.1007/s11423-020-09866-2

Hall, J. A., Widdall, C., & Lei, J. (2021). Preparing for virtual student teaching: a presence + experience design case. *TechTrends, 65*(6), 963-976. https://doi.org/10.1007/s11528-021-00660-2

Harris, J. B., & Hofer, M. J. (2011). Technological Pedagogical Content Knowledge (TPACK) in action: A descriptive study of secondary teachers' curriculum-based, technology-related instructional planning. *Journal of Research on Technology in Education, 43*(3), 211-229. https://doi.org/10.1080/15391523.2011.10782570

Harris, J. B., Grandgenett, N., & Hofer, M. J. (2010). Testing a TPACK-based technology integration assessment rubric. *Society for Information Technology & Teacher Education International Conference, (1)*, 3833-3840.

Harris, L., Dargusch, J., Ames, K., & Bloomfield, C. (2020). Catering for 'very different kids': distance education teachers' understandings of and strategies for student engagement. *International Journal of Inclusive Education*, 1-17. https://doi.org/10.1080/13603116.2020.1735543

Harris-Packer, J. D., & Ségol, G. (2015). An empirical evaluation of distance learning's effectiveness in the K–12 setting. *American Journal of Distance Education, 29*(1), 4-17. https://doi.org/10.1080/08923647.2015.990768

Harvey, D. M. & Caro, R. (2017). Building TPACK in preservice teachers through explicit course design. *TechTrends, 61*(2), 106-114. https://doi.org/10.1080/1475939X.2019.1569554

Hashey, A.I., & Stahl, S. (2014). Making online learning accessible for students with disabilities. *Teaching Exceptional Children, 46*(5), 70-78. https://doi.org/10.1177/0040059914528329

Havard, B., Nguyen, G. N., & Otto, B. (2018). The impact of technology use and teacher professional development on U.S. national assessment of educational progress

(NAEP) mathematics achievement. *Education and Information Technologies, 23*(5), 1897-1918. https://doi.org/10.1007/s10639-018-9696-4

Hawkins, A., Graham, C., Sudweeks, R., & Barbour, M. (2013). Academic performance, course completion rates, and student perception of the quality and frequency of interaction in a virtual high school. *Distance Education, 34*(1), 64-83. https://doi.org/10.1080/01587919.2013.770430

Heissel, J. (2016). The relative benefits of live versus online delivery: Evidence from virtual algebra I in North Carolina. *Economics of Education Review, 53*, 99-115. https://doi.org/10.1016/j.econedurev.2016.05.001

Higashi, R., Schunn, C., & Flot, J. (2017). Different underlying motivations and abilities predict student versus teacher persistence in an online course. *Educational Technology Research & Development, 65*(6), 1471-1493. https://doi.org/10.1007/s11423-017-9528-z

Hill, J. E. & Uribe-Florez, L. (2019). Understanding secondary school teachers' TPACK and technology implementation in mathematics classrooms. *International Journal of Technology in Education, 3*(1), 1-13. https://doi.org/10.46328/ijte.v3i1.8

Hinderliter, H., Xie, Y., Ladendorf, K., & Muehsler, H. (2021). Path analysis of internal and external factors associated with parental satisfaction over K-12 online learning. *Computers in the Schools, 38*(4), 354-383. https://doi.org/10.1080/07380569.2021.1988319

Hofer, M. & Grandgenett, N. (2012). TPACK development in teacher education: A longitudinal study of preservice teachers in a secondary M.A.Ed. Program.

Journal of Research on Technology in Education, 45(1), 83-106. https://doi.org/10.1080/15391523.2012.10782598

Holmberg, J., Fransson, G., & Fors, U. (2018). Teachers' pedagogical reasoning and reframing of practice in digital contexts. *The International Journal of Information and Learning Technology, 35*(2), 130-142. https://doi.org/10.1108/IJILT-09-2017-0084

Honey, S. (2018). Graphics calculators in the primary classroom: Student-teachers' beliefs and the TPACK framework. *The International Journal for Technology in Mathematics Education, 25*(3), 3-16.

Horzum, M. B., Akgün, O. E., & Öztürk, E. (2014). The psychometric properties of the technological pedagogical content knowledge scale. *International Online Journal of Educational Sciences, 6*(3), 544-557. https://iojes.net/?mod=makale_tr_ozet&makale_id=41011

Howland, J. L., Jonassen, D. H., & Marra, R. M. (2013). *Meaningful Learning with Technology: Pearson New International Edition* (4th ed.). Boston, MA: Pearson Higher Ed.

Hsu, L. & Chen, Y. J. (2018). Teachers' knowledge and competence in the digital age: Descriptive research within the TPACK framework. *International Journal of Information and Education Technology, 8*(6), 455-458. https://doi.org/10.18178/ijiet.2018.8.6.1081

Hsu, L & Chen, Y. J. (2019). Examining teachers' technological pedagogical and content knowledge in the era of cloud pedagogy. *South African Journal of Education, 39*, S1-S13. https://doi.org/10.15700/saje.v39ns2a1572

Hu, M., Arnesen, K., Barbour, M. K., Leary, H. (2019). A newcomer's lens: A look at K-12 online and blended learning in the journal of online learning research. *Journal of Online Learning Research, 5*(2), 123-144. https://files.eric.ed.gov/fulltext/EJ1229417.pdf

Huang, L., Li, S., Poitras, E. G., & Lajoie, S. P. (2021). Latent profiles of self-regulated learning and their impacts on teachers' technology integration. *British Journal of Educational Technology, 52*(2), 695-713. https://doi.org/10.1111/bjet.13050

Hung, J.L., Hsu, Y.C., & Rice, K. (2012). Integrating data mining in program evaluation of K-12 online education. *Educational Technology & Society, 15*(3), 27-41. https://www.jstor.org/stable/jeductechsoci.15.3.27

Hutchison, A. & Colwell, J. (2016). Preservice teachers' use of the technology integration planning cycle to integrate iPads into literacy instruction. *Journal of Research on Technology in Education, 48*(1), 1-15. https://doi.org/10.1080/15391523.2015.1103146

iNACOL. (2011). National standards for quality online teaching. Vienna, VA: International Association for K-12 Online Learning. https://files.eric.ed.gov/fulltext/ED509638.pdf

Individuals With Disabilities Education Improvement Act of 2004 (IDEA), H.R 1350, 108th Cong. (2004). https://www.congress.gov/bill/108th-congress/house-bill/1350/text

Jackson, B. L., & Jones, W. M. (2019). Where the rubber meets the road: Exploring the perceptions of in-service teachers in a virtual field experience. *Journal of*

Research on Technology in Education, 51(1), 7-26. https://doi.org/10.1080/15391523.2018.1530622

Jansen, C., & Van Der Merwe, P. (2015). Teaching practice in the 21st century: Emerging trends, challenges and opportunities. *Universal Journal of Educational Research, 3*(3), 190-199. https://files.eric.ed.gov/fulltext/EJ1056080.pdf

Johnson, E. S., Zheng, Y., Crawford, A. R., & Moylan, L. A. (2019). Developing an explicit instruction special education teacher observation rubric. *The Journal of Special Education, 53*(1), 28-40. https://dx.doi.org/10.1177/0022466918796224

Jones, K. D., & Figueiredo-Brown, R. (2018). Finding the customers: Challenges and experiences marketing K-12 full-time virtual schools. *American Journal of Distance Education, 32*(2), 96-112. https://doi.org/10.1080/08923647.2018.1440463

Jordan, K. (2013). The influence of gender on beginning teachers' measurement of TPACK knowledge. *Australian Educational Computing, 28*(2), 1-21. http://journal.acce.edu.au/index.php/AEC/article/view/21

Kadıoğlu-Akbulut, C., Çetin-Dindar, A., Küçük, S., & Acar-Şeşen, B. (2020). Development and validation of the ICT-TPACK-Science scale. *Journal of Science Education and Technology, 29*(3), 355-368. https://doi.org/10.1007/s10956-020-09821-z

Kartal, T. & Afacan, O. (2016). Examining Turkish pre-service science teachers' technological pedagogical content knowledge (TPACK) based on demographic variables. *Journal of Turkish Science Education, 14*(1), 1-22. https://tused.org/index.php/tused/article/view/133

Kaya, S. and DaĞ, F. (2013). Turkish adaptation of technological pedagogical content knowledge survey for elementary teachers. *Educational Sciences: Theory & Practice, 13*(1), 302-306. https://files.eric.ed.gov/fulltext/EJ1016741.pdf

Kazu, I. Y., & Erten, P. (2014). Teachers' technological pedagogical content knowledge self-efficacies. *Journal of Education and Training Studies, 2*(2), 126-144. https://doi.org/10.11114/jets.v2i2.261

Ke, F., & Hsu, Y. C. (2015). Mobile augmented-reality artifact creation as a component of mobile computer-supported collaborative learning. *The Internet and Higher Education, 26*, 33-41. https://doi.org/10.1016/j.iheduc.2015.04.003

Keith, T. Z. (2019). *Multiple Regression and Beyond: An Introduction to Multiple Regression and Structural Equation Modeling (*3rd ed.). New York, NY: Routledge.

Kennedy, K., & Archambault, L. (2012). Offering preservice teachers field experiences in K-12 online learning: A national survey of teacher education programs. *Journal of Teacher Education, 63*(3), 185-200. https://doi.org/10.1177/0022487111433651

Kennedy, K., Cavanaugh, C., & Dawson, K. (2013). Preservice teachers' experience in a virtual school. *American Journal of Distance Education, 27*(1), 56-67. https://doi.org/10.1080/08923647.2013.756757

Khine, M. S., Ali, B., & Afari, E. (2017). Exploring relationships among TPACK constructs and ICT achievement among trainee teachers. *Education and*

Information Technologies, 22(4), 1605-1621. https://doi.org/10.1007/s10639-016-9507-8

Kihoza, P., Zlotnikova, I., Bada, J., & Kalegele, K. (2016). Classroom ICT integration in Tanzania: Opportunities and challenges from the perspectives of TPACK and SAMR models. *International Journal of Education and Development using Information and Communication Technology, 12*(1), 107-128. https://files.eric.ed.gov/fulltext/EJ1099588.pdf

Kim, J. Y., & Fienup, D. M. (2021). Increasing access to online learning for students with disabilities during the COVID-19 pandemic. *The Journal of SpecEd, 55*(4), 213-221. 10.1177/0022466921998067

Koehler, M. J. & Mishra, P. (2005). What happens when teachers design educational technology? The development of Technological Pedagogical Content Knowledge. *Journal of Educational Computing Research. 32*(2), 131-152. https://doi.org/10.2190%2F0EW7-01WB-BKHL-QDYV

Koehler, M. J. & Mishra, P. (2009). What is technological pedagogical content knowledge? *Contemporary Issues in Technology and Teacher Education, 9*(1), 60-70. https://citejournal.org/wp-content/uploads/2016/04/v9i1general1.pdf

Koh, J. H. L., & Chai, C. S. (2014). Teacher clusters and their perceptions of technological pedagogical content knowledge (TPACK) development through ICT lesson design. *Computers & Education, 70*, 222-232. https://doi.org/10.1016/j.compedu.2013.08.017

Koh, J. H. L., & Chai, C. S. (2016). Seven design frames that teachers use when considering technological pedagogical content knowledge (TPACK). *Computers & Education, 102,* 244-257. https://doi.org/10.1016/j.compedu.2016.09.003

Koh, J. H. L., Chai, C. S., & Tay, L. Y. (2014a). TPACK-in-Action: Unpacking the contextual influences of teachers' construction of technological pedagogical content knowledge (TPACK). *Computers & Education, 78*, 20-29. https://doi.org/10.1016/j.compedu.2014.04.022

Koh, J. H. L., Chai, C. S., & Tsai, C. C. (2014b). Demographic factors, TPACK constructs, and teachers' perceptions of constructivist-oriented TPACK. *Journal of Educational Technology & Society, 17*(1), 185-196. http://www.jstor.org/stable/jeductechsoci.17.1.185

Kontkanen, S., Dillon, P., Valtonen, T., Eronen, L., Koskela, H., & Väisänen, P. (2016). Students' experiences of learning with iPads in upper secondary school - A base for proto-TPACK. *Education and Information Technologies, 22*(4), 1299-1326. https://doi.org/10.1007/s10639-016-9496-7

Kontkanen, S., Dillon, P., Valtonen, T., Renkola, S., Vesisenaho, M., & Väisänen, P. (2014). Pre-service teachers' experiences of ICT in daily life and in educational contexts and their proto-technological pedagogical knowledge. *Education and Information Technologies, 21*(4), 919-943. https://doi.org/10.1007/s10639-014-9361-5

Kopcha, T. J., Ottenbreit-Leftwich, A., Jung, J., & Baser, D. (2014). Examining the TPACK framework through the convergent and discriminant validity of two measures. *Computers & Education, 78*, 87-96. https://doi.org/10.1016/j.compedu.2014.05.003

Kruger, J., & Dunning, D. (2009). Unskilled and unaware of it: How difficulties in recognizing one's own incompetence lead to inflated self-assessments. *Journal of Personality and Social Psychology, 77*(6), 1121-1134. https://psycnet.apa.org/buy/1999-15054-002

Ku, C. J., Loh, W. L. L., Lin, K. Y., & Williams, J. P. (2021). Development of an instrument for exploring preservice technology teachers' maker-based technological pedagogical content knowledge. *British Journal of Educational Technology, 52*(2), 552-568. https://doi.org/10.1111/bjet.13039

Kumar, S., & Gangmei, E. (2018). Technological pedagogical content knowledge of secondary teacher educators of Jharkhand: An analysis. *International Journal of Innovative Studies in Sociology and Humanities, 3*(8), 31-38. https://ijissh.org/storage/Volume3/Issue8/IJISSH-030805.pdf

Kumi-Yeboah, A., Dogbey, J., & Guangji, Y. (2018). Exploring factors that promote online learning experiences and academic self-concept of minority high school students. *Journal of Research on Technology in Education, 50*(1), 1-17. https://doi.org/10.1080/15391523.2017.1365669

Kurban, K. (2020). Characterizing middle grade mathematics teachers' technological pedagogical content knowledge (TPACK) using a robust data set. *The Texas Forum of Teacher Education, 10*, 3-16. https://txate.org/resources/Documents/Kurban%202020.pdf

Lee, M. H. & Tsai, C. C. (2010). Exploring teachers' perceived self-efficacy and Technological Pedagogical Content Knowledge with respect to educational use of the World Wide Web. *Instructional Science, 38*. 1-21. https://doi.org/10.1007/s11251-008-9075-4

Lehiste, P. (2015). The impact of a professional development program on in-service teachers' TPACK: A study from Estonia. *Problems of Education in the 21st Century, 66*, 18-28. http://oaji.net/articles/2015/457-1441441936.pdf

Linneberg, M. S., & Korsgaard, S. (2019). Coding qualitative data: a synthesis guiding the novice. *Qualitative Research Journal, 19*(3), 259-270. https://doi.org/10.1108/QRJ-12-2018-0012

Louwrens, N., & Hartnett, M. (2015). Student and teacher perceptions of online student engagement in an online middle school. *Journal of Open, Flexible & Distance Learning, 19*(1), 27-44.

Love, M. L., & Ewoldt, K. B. (2021). Implementing asynchronous instructional materials for students with learning disabilities. *Intervention in School & Clinic, 57*(2), 132-137. https://doi.org/10.1177/10534512211001847

Lu, L. & Wang, W. (2021). Chinese pre-service teachers' technology use experiences and their technological pedagogical content knowledge. *Educational Research Quarterly, 44*(3), 34-55, 57-60. https://doi.org/10.1177%2F0735633115585929

Luo, T., Hibbard, L., Franklin, T., & Moore, D. R. (2017). Preparing teacher candidates for virtual field placements via an exposure to K-12 online teaching. *Journal of Information Technology Education, 16*(1), 1-14. https://doi.org/10.28945/3626

Maccini, P., & Gagnon, J. C. (2002). Perceptions and applications of NCTM standards by special and general education teachers. *Exceptional Children, 68*(3), 325-345. https://doi.org/10.1177/001440290206800303

Maccini, P., & Gagnon, J. C. (2006). Mathematics instructional practices and assessments accommodations by secondary general and special educators. *Exceptional Children, 72*(2), 217-234. https://doi.org/10.1177/001440290607200206

Maeng, J. L., Mulvey, B. K., Smetana, L. K., & Bell, R. L. (2013). Preservice teachers' TPACK: Using technology to support inquiry instruction. *Journal of Science Education and Technology, 22*(6), 838-857. https://doi.org/10.1007/s10956-013-9434-z

Marino, M. T, Sameshima, P., & Beecher, C. C. (2009). Enhancing TPACK with assistive technology: Promoting inclusive practices in pre-service teacher education. *Contemporary Issues in Technology and Teacher Education, 9*(2), 186-207. https://citejournal.org/volume-9/issue-2-09/general/enhancing-tpack-with-assistive-technology-promoting-inclusive-practices-in-preservice-teacher-education/

Marteney, T., & Bernadowski, C. (2016). Teachers' perceptions of the benefits of online instruction for students with SpecEdal needs. *British Journal of SpecEd, 43*(2). https://doi.org/10.1111/1467-8578.12129

Martin, B. (2018). Faculty technology beliefs and practices in teacher preparation through a TPACK lens. *Education and Information Technologies, 23*(5), 1775-1788. https://doi.org/10.1007/s10639-017-9680-4

Martin, F., Bacak, J., Polly, D., & Dymes, L. (2020). A systematic review of research on K12 online teaching and learning: Comparison of research from two decades 2000 to 2019. *Journal of Research on Technology in Education*, 1-20. https://doi.org/10.1080/15391523.2021.1940396

Martin, F., Xie., K., Bollinger., D. U. (2022). Engaging learners in the emergency transition to online learning during the COVID-19 pandemic. *Journal of Research on Technology in Education, 54*(1), 1-13. https://doi.org/10.1080/15391523.2021.1991703

Martin, J. L. (2016). Special Education in Online and Virtual School Programs. https://www.ksde.org/Portals/0/SES/legal/conf17/Martin-VirtualPrograms.pdf

Martin, T. N. (2017). Let's get poppin' with BrainPOP: An educational web site. *Delta Kappa Gamma Bulletin*, *83*(4), 53–54.

McLeskey, J., Barrington, M. D., Billingsly, B., Brownell, M., Jackson, D., Kennedy, M., Lewis, T., Maheady, L., Rodriguez, J., Scheeler, M. C., Winn, J., & Zeigler, D. (2017, January). *High-leverage practices in SpecEd*. Council for Exceptional Children.

Means, B., Toyama, Y., Murphy, R., & Baki, M. (2013). The effectiveness of online and blended learning: A meta-analysis of empirical literature. *Teachers College Record, 115*(3), 1-47.

Messina, L. & Tabone, S. (2015). Technology proficiency, TPACK and beliefs about technology: A survey with primary school student teachers. *Research on Education and Media, 5*(1), 11-30.

Meyer, A., Rose, D. H., & Gordon, D. (2014). *Universal Design for Learning: Theory & practice.* CAST Professional Publishing. http://udltheorypractice.cast.org/

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

Minicozzi, L. L. (2018). iPads and pre-service teaching: exploring the use of iPads in k-2 classrooms. *The International Journal of Information and Learning Technology, 35*(3), 160-180. https://doi.org/10.1108/IJILT-05-2017-0032

Miron, G., Gulosino, C., & Horvitz, B. (2014). Section III: Full time virtual schools. In A. Molnar (Ed.), Virtual schools in the U.S. 2014 (pp. 55–73). Boulder, CO: National Education Policy Center. http://nepc.colorado.edu/files/vir tual-2014-all-final.pdf

Miron, G., Barbour, M. K., Huerta, L., Shafer, S. R., Rice, J. K., Glover, A., Browning, N., Hagle, S., & Boninger, F. (2021). In A. Molnar (Ed.), Virtual schools in the U.S. 2021. Boulder, CO: National Education Policy Center. http://nepc.colorado.edu/publication/virtual-schools-annual-2021

Moore, M. G. (1989). Three types of interaction. *American Journal of Distance Education, 3*(2), 1–7. https://eddl.tru.ca/wp-content/uploads/2019/08/EDDL5101_W9_Moore_1989.pdf

Moore, M. G. (1997). Theory of transactional distance. In D. Keegan (Ed.), Theoretical principles of distance education (pp. 22–38). New York: Routledge.

Moore-Adams, B. L., Jones, W. M., & Cohen, J. (2016). Learning to teach online: a systematic review of the literature on K-12 teacher preparation for teaching online. *Distance education, 37*(3), 333-348. https://doi.org/10.1080/01587919.2016.1232158

Morgan, D. L. (2019). Commentary - after triangulation, what next? *Journal of Mixed Methods Research, 13*(1), 6-14. https://doi.org/10.1177/1558689818780596

Morgan, H. (2015). Online Instruction and Virtual Schools for Middle and High School Students: Twenty-First-Century Fads or Progressive Teaching Methods for Today's Pupils? Clearing House, 88(2), 72-76. doi:10.1080/00098655.2015.1007909

Morrow-Howell, N. (1994). The M word: Multicollinearity in multiple regression. Social Work Research, 18(4), 247–251. https://psycnet.apa.org/doi/10.1093/swr/18.4.247

Mouza, C. (2011). Promoting urban teachers' understanding of technology, content, and pedagogy in the context of case development*. Journal of Research on Technology in Education, 44*(1), 1-29. https://doi.org/10.1080/15391523.2011.10782577

Mouza, C. & Karchmer-Klein, R. (2013). Promoting and assessing pre-service teachers' technological pedagogical content knowledge (TPACK) in the context of case development. *Journal of Educational Computing Research, 48*(2), 127-152. https://doi.org/10.2190%2FEC.48.2.b

Mtebe, J. S. & Raphael, C. (2018). Eliciting in-service teachers' technological pedagogical content knowledge for 21st-century skills in Tanzania. *Journal of Learning for Development, 5(*3), 263-279. https://jl4d.org/index.php/ejl4d/article/view/288

National Center for Education Statistics. (2022). Students With Disabilities. *Condition of Education*. U.S. Department of Education, Institute of Education Sciences. Retrieved [date], from https://nces.ed.gov/programs/coe/indicator/cgg.

Natale, C. F., & Cook, J. (2012). Virtual K–12 learning: New learning frontiers for state education agencies. *Peabody Journal of Education, 87*(5), 535-558. https://doi.org/10.1080/0161956X.2012.723491

Oakley, G., Howitt, C., Garwood, R., & Durack, A. R. (2013). Becoming multimodal authors: Pre-service teachers' interventions to support young children with autism. *Australasian Journal of Early Childhood, 38*(3), 86-96. https://doi.org/10.1177%2F183693911303800311

Ortiz, K. R., Rice, M.F., Curry, T., Mellard, D., & Kennedy, K. (2021). Parent perceptions of online school support for children with disabilities. *American Journal of Distance Education, 35*(4). https://doi.org/10.1080/08923647.2021.1979343

Osborne, J. W., & Waters, E. (2002). Four assumptions of multiple regression that researchers should always test. *Practical Assessment, Research, and Evaluation, 8*(2). https://doi.org/10.7275/r222-hv23

Ozudogru, M. & Ozudogru, F. (2019). Technological Pedagogical Content Knowledge of Mathematics Teachers and the Effect of Demographic Variables. *Contemporary Educational Technology, 10*(1), 1-24. https://doi.org/10.30935/cet.512515

Petty, T., Wang, C., & Harbaugh, A. P. (2013). Relationships between student, teacher, and school characteristics and mathematics achievement. *School Science and Mathematics, 113*(7), 333-344. https://doi.org/10.1111/ssm.12034

Picciano, A. G., Seaman, J., Shea, P., & Swan, K. (2012). Examining the extent and nature of online learning in American K-12 Education: The research initiatives of the Alfred P. Sloan Foundation. *Internet & Higher Education, 15*(2), 127-135. https://doi.org/10.1016/j.iheduc.2011.07.004

Piret, L., Taimalu, M., & Suviste, R. (2018). Perceptions of technological, pedagogical and content knowledge (TPACK) among pre-service teachers in Estonia. *Education and Information Technologies, 23*(2), 741-755. https://doi.org/10.1007/s10639-017-9633-y

Prensky, M. (2001). Digital Natives, Digital Immigrants. *On the Horizon, 9*(5), 1-6. https://www.marcprensky.com/writing/Prensky%20-%20Digital%20Natives,%20Digital%20Immigrants%20-%20Part1.pdf

Pringle, R. M., Dawson, K., & Ritzhaupt, A. D. (2015). Integrating science and technology: Using technological pedagogical content knowledge as a framework to study the practices of science teachers. *Journal of Science Education and Technology, 24*(5), 648-662. https://doi.org/10.1007/s10956-015-9553-9

Pulham, E., & Graham, C. R. (2018). Comparing K-12 online and blended teaching competencies: a literature review. *Distance education, 39*(3), 411-432. https://doi.org/10.1080/01587919.2018.1476840

Rakes, G. C., & Dunn, K. E. (2015). Teaching Online: Discovering Teacher Concerns. Journal of *Research on Technology in Education, 47*(4), 229-241. https://doi.org/10.1080/15391523.2015.1063346

Ramakrishnan, R. S., Salleh, N. M., & Alias, A. (2020). The level of special education teachers' technological pedagogy and content knowledge, teaching style, self-efficacy and competency. *Universal Journal of Educational Research, 8*(11a), 89-96. https://doi.org/10.13189/ujer.2020.082111

Rice, K. L. (2006). A comprehensive look at distance education in the K-12 context. *Journal of Research on Technology in Education, 38*(4), 425-448. https://doi.org/10.1080/15391523.2006.10782468

Rice, M. (2017). Few and far between: Describing K-12 online teachers' online professional development opportunities for students with disabilities. *Online Learning, 21*(4), 103-121. https://doi.org/10.24059/olj.v21i4.1274

Rice, M. F., & Carter, A. C. (2016). Online teacher work to support self-regulation of learning in students with disabilities at a fully online state virtual school. *Online Learning, 20*(4), 118-135.

Rice, M. F., Ortiz, K. R., Curry, T. M., & Petropoulos, R. (2019). A case study of a foster parent working to support a child with multiple disabilities in a full-time virtual school. *Journal of Online Learning Research, 5*(2), 145-168. https://files.eric.ed.gov/fulltext/EJ1229408.pdf

Riccomini, P., Morano, S., & Hughes, C. A. (2017). Big ideas in SpecEd: Specially designed instruction, high-leverage practices, explicit instruction, and intensive instruction. *Teaching Exceptional Children, 50*(1), 20-27. https://doi.org/10.1177/0040059917724412

Roscoe, J.T. (1975) *Fundamental Research Statistics for the Behavioural Sciences (2nd ed)*. New York: Holt Rinehart & Winston.

Ruppar, A. L., Roberts, C.A., & Olson, A. J. (2017). Perspectives about expert teaching for students with severe disabilities among teachers identified as experts.

Research and Practice for Persons with Severe Disabilities, 42(2), 121-135. https://doi.org/10.1177/1540796917697311

Sahin, I. (2011). Development of survey of technological pedagogical and content knowledge (TPACK). *TOJET: The Turkish Online Journal of Educational Technology, 10*(1), 97-105. https://files.eric.ed.gov/fulltext/EJ926558.pdf

Saltan, F. (2017). Online case-based learning design for facilitating classroom teachers' development of technological, pedagogical, and content knowledge. *European Journal of Contemporary Education, 6*(2), 308-316. https://doi.org/10.13187/ejced.2017.2.308

Saubern, R., Henderson, M., Heinrich, E., & Redmond, P. (2020). TPACK – time to reboot? *Australasian Journal of Educational Technology, 36*(3), 1-9. https://doi.org/10.14742/ajet.6378

Scherer, R., Tondeur, J., & Siddiq, F. (2017). On the quest for validity: Testing the factor structure and measurement invariance of the technology-dimensions in the Technological, Pedagogical, and Content Knowledge (TPACK) model. *Computers & Education, 112*, 1-17. https://doi.org/10.1016/j.compedu.2017.04.012

Schmid, M., Brianza, E., & Petko, D. (2020). Developing a short assessment instrument for technological pedagogical content knowledge (TPACK.xs) and comparing the factor structure of an integrative and a transformative model. *Computers & Education, 157,* 103967, 1-12. https://doi.org/10.1016/j.compedu.2020.103967

Schmid, M., Brianza, E., & Petko, D. (2021). Self-reported technological pedagogical content knowledge (TPACK) of pre-service teachers in relation to digital technology use in lesson plans. *Computers in Human Behavior, 115*, 1-12. https://doi.org/10.1016/j.chb.2020.106586

Schmidt, D. A., Baran, E., Thompson, A. D., Mishra, P., Koehler, M. J., & Shin, T. S. (2009). Technological Pedagogical Content Knowledge (TPACK): The development and validation of an assessment instrument for preservice teachers. *Journal of Research on Technology in Education, 42*(2), 123-149. https://files.eric.ed.gov/fulltext/EJ868626.pdf

Scrabis-Fletcher, K., Juniu, S., & Zullo, E. (2016). Preservice physical education teachers' technological pedagogical content knowledge." *Physical Educator, 73*(4), 704-718. https://doi.org/10.18666/TPE-2016-V73-I4-6818

Seyit, A. K., Celik, I., & Çolakoğlu, M. H. (2018). TPACK self-efficacy perceptions of science teachers: A structural equation modeling study. *Egitim ve Bilim, 43*(195), 253-268. https://doi.org/10.15390/EB.2018.7538

Shaheen, N. L., & Watulak, S. L. (2018). Bringing disability into the discussion: Examining technology accessibility as an equity concern in the field of instructional technology. *Journal of Research on Technology in Education, 51*(2), 187-201. https://doi.org/10.1080/15391523.2019.1566037

Shinas, V. H., Yilmaz-Ozden, S., Mouza, C., Karchmer-Klein, R., & Glutting, J. J. (2013). Examining domains of technological pedagogical content knowledge using factor analysis. *Journal of Research on Technology in Education, 45*(4), 339-360. https://doi.org/10.1080/15391523.2013.10782609

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4-14. https://doi.org/10.2307/1175860

Smith, M. & Garret, S. (2021). High leverage practices create transformative learning amid COVID-19. *Delta Kappa Gamma Bulletin, 87*(5), 50-55.

Smith, S. J., & Harvey, E. E. (2014). K-12 online lesson alignment to the principles of Universal Design for Learning: The Khan Academy. *Open Learning, 29*(3), 222-242. https://doi.org/10.1080/02680513.2014.992402

Smith, S. J., Basham, J., Rice, M. F., & Carter Jr., R.A. (2016). Preparing special educators for the K-12 online learning environment: A survey of teacher educators. *Journal of SpecEd Technology, 31*(3), 170-178. https://doi.org/10.1177/0162643416660834

Sorensen, T. (2019). SpecEd in Idaho virtual schools: An analysis of the efficacy of service delivery. *ProQuest Dissertations Publishing.*

Spitler, C., Repetto, J., & Cavanaugh, C. (2013). Investigation of a SpecEd program in a public cyber charter school. *American Journal of Distance Education, 27*(1), 4-15. https://doi.org/10.1080/08923647.2013.754182

Tawfik, A. A., Shepherd, C. E., Gatewood, J., & Gish-Lieberman, J. J. (2021). First and second order barriers to teaching in K-12 online learning. *TechTrends, 65*(6), 925-938. https://doi.org/10.1007/s11528-021-00648-y

Timur, B., & Tasar, M.F. (2011). The adaptation of the Technological Pedagogical Content Knowledge confidence survey into Turkish. *Gaziantep University Journal of Social Sciences, 10*, 839-856.

Thompson, L.A., Ferdig, R., & Black, E. (2012). Online schools and children with special health and educational needs: Comparison with performance in traditional schools. *Journal of Medical Internet Research, 14*(3), 1-9. https://doi.org/10.2196/jmir.1947

Tokmak, H. S., Yelken, T. Y., & Konokman, G. Y. (2013). Pre-service teachers' perceptions on development of their IMD competencies through TPACK-based activities. *Journal of Educational Technology & Society, 16*(2), 243-256.

Tondeur, J., Scherer, R., Siddiq, F., & Baran, E. (2020). Enhancing pre-service teachers' technological pedagogical content knowledge (TPACK): a mixed-method study. *Educational Technology Research and Development, 68*(1), 319-343. https://doi.org/10.1007/s11423-019-09692-1

Tonks, D., Kimmons, R., & Mason, S. L. (2021). Motivations among SpecEd students and their parents for switching to an online school: Survey responses and emergent themes. *Online Learning, 25*(2), 171-189. https://doi.org/10.24059/olj.v25i2.2141

Tournaki, N. and I. Lyublinskaya (2014). Preparing special education teachers for teaching mathematics and science with technology by integrating TPACK framework into the curriculum: A study of teachers' perceptions. *Journal of Technology and Teacher Education, 22*(2), 243-259. https://www.learntechlib.org/p/43833/

Traga Philippakos, Z.A. (2021). Think aloud modeling: Expert and coping models in writing instruction and literacy pedagogy. *The Language and Literacy Spectrum, 31*(1). https://files.eric.ed.gov/fulltext/EJ1303499.pdf

Tseng, J. J. (2018). Exploring TPACK-SLA interface: Insights from the computer-enhanced classroom. *Computer Assisted Language Learning, 31*(4), 390-412. https://doi.org/10.1080/09588221.2017.1412324

Valtonen, T., & Kukkonen, J. (2015). Developing a TPACK measurement instrument for 21st century pre-service teachers. *Seminar.net - International Journal of Media, Technology, and Lifelong Learning, 11*(2), 87-100. https://journals.oslomet.no/index.php/seminar/article/view/2353

Valtonen, T., Leppänen, U., Hyypiä, M., Sointu, E., Smits, A., & Tondeur, J. (2020). Fresh perspectives on TPACK: pre-service teachers' own appraisal of their challenging and confident TPACK areas. *Education and Information Technologies, 25*(4), 2823-2842. https://doi.org/10.1007/s10639-019-10092-4

Valtonen, T., Sointu, E., Kukkonen, J., Kontakten, S., Lambert, M.C., & Mäkitalo-Siegl, K. (2017). TPACK updated to measure pre-service teachers' twenty-first century skills. *Australasian Journal of Educational Technology, 33*(3), 15-31. https://doi.org/10.14742/ajet.3518

Valtonen, T., Sointu, E., Kukkonen, J., Mäkitalo, K., Hoang, N., Häkkinen, P., Järvelä, S., Näykki, P., Virtanen, A., Pöntinen, S., Kostiainen, E., & Tondeur, J. (2019). Examining pre-service teachers' technological pedagogical content knowledge as evolving knowledge domains: A longitudinal approach. *Journal of Computer Assisted Learning, 35*(4), 491-502. https://doi.org/10.1111/jcal.12353

Vasquez, E., & Serianni, B. A. (2012). Research and practice in distance education for K-12 students with disabilities. *Rural SpecEd Quarterly, 31*(4), 33-42. https://doi.org/10.1177/875687051203100406

Viano, S. L. (2018). At-risk high school students recovering course credits online: What we know and need to know. *American Journal of Distance Education, 32*(1), 16-26. https://doi.org/10.1080/08923647.2018.1412554

Voogt, J., Fisser, P., Roblin, N.P., Tondeur, J., & Van Braak, J. (2013). Technological pedagogical content knowledge – a review of the literature. *Journal of Computer Assisted Learning, 29*(2), 109-121. https://doi.org/10.1111/j.1365-2729.2012.00487.x

Ward, C. L., Kushner-Benson, S. N. (2010). Developing new schemas for online teaching and learning: TPACK. *MERLOT Journal of Online Learning and Teaching, 6*(2), 482-490. https://jolt.merlot.org/vol6no2/ward_0610.pdf

Waters, L. H., Barbour, M. K., & Menchaca, M. P. (2014). The nature of online charter schools: Evolution and emerging concerns. *Journal of Educational Technology & Society, 17*(4), 379-389.

Wen, H. & Shinas, V. H. (2021). Using a multidimensional approach to examine TPACK among teacher candidates. *Journal of Digital Learning in Teacher Education, 37*(1), 30-47. https://doi.org/10.1080/21532974.2020.1804493

Wray, N., Markovic, M., & Manderson, L. (2007). “Researcher saturation”: The impact of data triangulation and intensive-research practices on the researcher and qualitative research process. *Qualitative Health Research, 17*(10), 1392-1402. https://doi.org/10.1177/1049732307308308

Wright, N., & Peters, M. (2017). Sell, sell, sell or learn, learn, learn? The EdTech market in New Zealand’s education system – privatization by stealth? *Open Review of*

Educational Research, 4(1), 164-176. https://doi.org/10.1080/23265507.2017.1365623

Xie, K., Kim, M. K., Cheng, S. L., & Luthy, N. C. (2017). Teacher professional development through digital content evaluation. *Educational Technology Research and Development, 65*(4), 1067-1103. https://psycnet.apa.org/doi/10.1007/s11423-017-9519-0

Yeh, Y. F., Lin, T. C., Hsu, Y. S., Wu, H. K., & Hwang, F. K. (2015). Science teachers' proficiency levels and patterns of TPACK in a practical context. *Journal of Science Education and Technology, 24*(1), 78-90. http://doi.org/10.1007/s10956-014-9523-7

Yeh., Y. F., Hsu, Y. S., Wu, H. K., Hwang, F. K., & Lin, T. C. (2013). Developing and validating technological pedagogical content knowledge - practical (TPACK-Practical) through the Delphi Survey Technique. *British Journal of Educational Technology, 45*(4), 707-722. https://doi.org/10.1111/bjet.12078

Yerdelen-Damar, S., Boz, Y., & Aydın-Günbatar, S. (2017). Mediated effects of technology competencies and experiences on relations among attitudes towards technology use, technology ownership, and self-efficacy about technological pedagogical content knowledge. *Journal of Science Education and Technology, 26*(4), 394-405. http://doi.org/10.1007/s10956-017-9687-z

Young Ju, J., Park, S., & Lim, E. (2018). Factors influencing preservice teachers' intention to use technology: TPACK, teacher self-efficacy, and technology acceptance model. *Journal of Educational Technology & Society, 21*(3), 48-59. https://www.jstor.org/stable/26458506

Yulisman, H., Widodo, A., Riandi, R., & Nurina, C. I. E. (2019). Moderated effect of teachers' attitudes to the contribution of technology competencies on TPACK. *Jurnal Pendidikan Biologi Indonesia, 5*(2), 185-196. https://doi.org/10.22219/jpbi.v5i2.7818

Yurdakul, I. K., Odabasi, H. F., Kilicer, K., Coklar, A. N., Birinci, G., & Kurt, A. A. (2012). The development, validity, and reliability of TPACK-deep: A technological pedagogical content knowledge scale. *Computers & Education, 58*(3), 964-977. http://doi.org/10.1016/j.compedu.2011.10.012

Zelkowski, J., Gleason, J., Cox, D.C., & Bismarck, S. (2013). Developing and validating a reliable TPACK instrument for secondary mathematics preservice teachers. *Journal of Research on Technology in Education, 46*(2), 173-206. https://doi.org/10.1080/15391523.2013.10782618

Zheng, B., Lin, C.-H., & Kwon, J. B. (2020). The impact of learner-, instructor-, and course-level factors on online learning. *Computers & Education, 150*, 1-11. https://doi.org/10.1016/j.compedu.2020.103851

Zhou, Y., Chai, C. S., Liang, J. C., Jin, M., & Tsai, C. C. (2017). The relationship between teachers' online homework guidance and technological pedagogical content knowledge about educational use of web. *The Asia-Pacific Education Researcher, 26*(5), 239-247. https://doi.org/10.1007/s40299-017-0344-3

Zweig, J., Stafford, G., Hanita, M. (2022). Enrollment timing in supplementary online courses: Do students who enroll on time have better course outcomes? *Journal of Online Learning Research, 8*(2), 163-180.

APPENDIX A

The High Leverage Practices for Special Education

Collaboration

1. Collaborate with professionals to increase student success
2. Organize and facilitate effective meetings with professionals
3. Collaborate with families to support student learning and secure needed services

Assessment

1. Use multiple sources of information to develop a comprehensive understanding of a student's strengths and needs
2. Interpret and communicate assessment information with stakeholders to collaboratively design and implement educational programs
3. Use student assessment data, analyze instructional practices, and make necessary adjustments that improve student outcomes

Social/Emotional/Behavioral

1. Establish a consistent, organized, and respectful learning environment
2. Provide positive and constructive feedback to guide students' learning and behavior
3. Teach social behaviors
4. Conduct functional behavioral assessments to develop individual student behavior support plans

Instruction

1. Identify and prioritize long- and short-term learning goals
2. Systematically design instruction toward specific learning goals
3. Adapt curriculum tasks and materials for specific learning goals

4. Teach cognitive and metacognitive strategies to support learning and independence
5. Provide scaffolded supports
6. Use explicit instruction
7. Use flexible grouping
8. Use strategies to promote active student engagement
9. Use assistive and instructional technologies
10. Provide intensive instruction
11. Teach students to maintain and generalize new learning across time and settings
12. Provide positive and constructive feedback to guide students' learning and behavior

APPENDIX B

Demographic Survey

1. Please enter your date of birth:

[date input field provided for response]

2. Which option best describes your teacher certification status?

a. I have a standard teacher certificate for my state

b. I am a National Board-Certified Teacher and/or possess a professional level teaching certificate

c. I have a provisional or emergency certificate, and/or am working towards full certification

d. I do not have any teaching certification

e. Other (please explain) *[text input option]*

3. Do you possess a valid, state-issued special education teaching endorsement?

a. Yes

b. No

4. What is the highest level of education you have completed?

a. High school diploma

b. Some college

c. Associate degree

d. Bachelor's degree

e. Master's degree

f. Doctoral degree

5. How many years of total teaching experience do you have (in-person and/or virtual/online)?

*an answer of 0 means this is your first year of teaching.

(*Response option is drop down box with single years from "0" through "29". The final response option is "30+").*

6. How many years of *special education* teaching experience do you have (in-person and/or virtual/online)?

*an answer of 0 means this is your first year teaching special education.

(*Response option is a drop down box with single years from "0" through "29". The final response option is "30+").*

7. How many years of *online or virtual* teaching experience do you have?

*an answer of 0 means this is your first year teaching online.

(*Response option is a drop down box with single years from "0" through "29". The final response option is "30+").*

8. How many years of *online or virtual special education* teaching experience do you have?

*an answer of 0 means this is your first year teaching online special education.

(*Response option is a drop down box with single years from "0" through "29". The final response option is "30+").*

9. Does your online or virtual teaching experience include emergency remote teaching due to COVID-19 related school closures?

a. Yes
b. No

10. If you answered "Yes" to the above question, how many years did you spend in emergency remote teaching due to COVID-19 related school closures? *[optional item]*

a. 0-1
b. 1-2
c. 2-3
d. 3+

11. Please select any of the disability categories below for which the students you serve qualify for special education services:

a. Specific Learning Disability
b. Other Health Impairment
c. Intellectual Disability
d. Autism Spectrum Disorder
e. Emotional Disturbance
f. Speech or Language Impairment
g. Traumatic Brain Injury
h. Multiple Disabilities

i. Visual Impairment, including blindness
j. Deafness
k. Hearing Impairment
l. Deaf-Blindness
m. Orthopedic Impairment

12. Please select the state in which you are currently employed as an online special education teacher. If you work in multiple states, please select the state in which the bulk of your work resides.

(Drop down menu is provided with all 50 states plus an "other" option with a text input area)

13. Which option(s) below best describe your current employer? (Select all that apply).

a. Public school district
b. State education agency
c. A college or university
d. Other public education agency
e. Charter school agency
f. A private company that provides educational services to K-12 schools
g. Other (please specify)

APPENDIX C

TPACK.xs Survey

Adapted TPACK Survey (Schmid et al., 2020; Based on SPTKTT; Schmidt et al., 2009)

"Technology is a broad concept that can mean a lot of different things. For the purpose of this survey, 'technology' refers to digital technology/technologies - that is, the digital tools we use such as computers, laptops, iPads, handhelds, interactive whiteboards, software programs, LMS platforms, web applications, digital multimedia, etc. Please answer all of the questions with the most appropriate answer.
PLEASE NOTE: The term "classroom" in this survey refers to the online learning environment."

For each item: (Strongly Disagree = SD; Disagree = D; Neither Agree/Disagree = N; Agree = A; Strongly Agree = SA;)

Pedagogical Knowledge (PK)

1. I can adapt my teaching based upon what students currently understand or do not understand
2. I can adapt my teaching style to different learners
3. I can use a wide range of teaching approaches in a classroom setting
4. I can assess student learning in multiple ways

Content Knowledge (CK)

1. I have sufficient knowledge about my teaching subject
2. I can use a subject-specific way of thinking in my teaching subject
3. I know the basic theories and concepts of my teaching subject
4. I know the history and development of important theories in my teaching subject

Technological Knowledge (TK)

1. I keep up with important new technologies
2. I frequently play around with the technology
3. I know a lot of different technologies
4. I have the technical skills I need to use technology

Pedagogical Content Knowledge (PCK)

1. I know how to select effective teaching approaches to guide student thinking and learning in my teaching subject
2. I know how to develop appropriate tasks to promote students complex thinking of my teaching subject
3. I know how to develop exercises with which students' can consolidate their knowledge of my teaching subject
4. I know how to evaluate students' performance in my teaching subject

Technological Content Knowledge (TCK)

1. I know how technological developments have changed the field of my subject
2. I can explain which technologies have been used in research in my field
3. I know which new technologies are currently being developed in the field of my subject
4. I know how to use technologies to participate in scientific discourse in my field

Technological Pedagogical Knowledge (TPK)

1. I can choose technologies that enhance the teaching approaches for a lesson
2. I can choose technologies that enhance students' learning for a lesson
3. I can adapt the use of the technologies that I am learning about to different teaching activities

4. I am thinking critically about how to use technology in my classroom

Technological Pedagogical Content Knowledge (TPCK)

1. I can teach lessons that appropriately combine my teaching subject, technologies, and teaching approaches
2. I can use strategies that combine content, technologies, and teaching approaches that I learned about in my coursework in my classroom
3. I can choose technologies that enhance the content of a lesson
4. I can select technologies to use in my classroom that enhance what I teach, how I teach, and what students learn

APPENDIX D

Qualitative Questionnaire

“There are 10 open-ended written response questions in this section. You are encouraged to provide as much relevant detail as possible in response to each question.

These questions and prompts will inquire as to the instructional practices you implement in your role as an online special education teacher. If a prompt references an instructional practice you are not familiar with, or do not utilize in your teaching, please type “N/A”. Please do not leave any text boxes blank.

1. In your online teaching practice, what strategies and methods do you use to collaborate with colleagues and families to meet the academic, functional and social needs of your students?
2. In your online teaching practice, what strategies and methods do you use to collect and utilize student performance data to inform instruction?
3. In your online teaching practice, what methods and strategies do you use to meet students’ social, emotional and behavioral needs?
4. In your online teaching practice, what methods and strategies do you use to provide students with specially designed instruction (SDI) that addresses their needs and deficits?
5. What apps and/or technological tools do you use most often in your online teaching practice? For each app or tool listed, please briefly explain how you use it.
6. In your online teaching practice, what methods and strategies do you use to facilitate positive peer-to-peer interactions?

7. Describe some of the biggest challenges you've experienced in your work as an online special education teacher.
8. Describe what you believe are the greatest benefits or affordances of online learning for students with disabilities.
9. What advice would you give to a new online special education teacher?
10. Please use this space to provide any additional information related to your own online special education teaching practice you would like to share.