A Causal-comparative Study of Teacher Self-efficacy in Virtual Charter Schools

Lori Kennedy Alverson

Dissertation Submitted to the Doctoral Program

of the American College of Education

in partial fulfillment of the requirements for the degree of

Doctor of Education in Educational Leadership

January 2022

A Causal-comparative Study of Teacher Self-efficacy in Virtual Charter Schools

Lori Kennedy Alverson

Approved by:

Dissertation Chair: Jamie Ball, Ed.D.

Committee Member: Sandra Johnson, Ph.D.

Abstract

Teacher self-efficacy is the belief in the ability to impact students' success. There is limited research about teachers' self-efficacy levels in the virtual K–12 environment. Self-efficacy may play a key role in job satisfaction, teacher retention, and higher student achievement. Research literature focused on teaching preparation programs and faculty in higher education but was minimal for the K–12 context. This quantitative study aimed to increase the scope in the literature to K–12 virtual charter schools and determined if there were any significant statistical differences in teacher self-efficacy and attitudes towards science, technology, engineering, and math in the online setting. The theoretical foundation was the intersection of self-efficacy theory and servant leadership. The research questions determined if there were a statistically significant difference between teacher self-efficacy and attitudes towards STEM when compared across the subject matter of elementary, science, technology, engineering, and math, along with the comparison of virtual teaching experience. The causal–comparative design used purposive and snowball sampling methods. The 104 K–12 virtual teacher participants used the Teacher Efficacy and Attitudes Toward STEM Survey. Data was collected through Survey Monkey and then run through statistical analysis with SPSS software. The study results showed significant statistical differences in mean composite scores on the T-STEM survey across subject matter and years of virtual teaching experience groups. There was no statistical interaction between subject areas and years of virtual teaching experience. Leaders may survey the needs of their staff to determine their online teaching proficiency and provide support for gaps in proficiencies.

Keywords: self-efficacy, virtual charter school, STEM, K–12, servant leadership

Dedication

This dissertation is dedicated to my amazing husband and children. While each expressed wonder why I would want to pursue a doctorate as a hobby, they fully supported the time and energy that went into the process. Being the first generation to go to college coupled with imposter syndrome, doubt, and guilt about my time spent on the dissertation was often self-questioned. Eli, your encouragement did not go unnoticed, with the regular running to get Oreos or Coke Zeros. The act always helped me push a bit more. Bella and Charlotte, your nightly visits to the home office to ‘hang out’ were needed and appreciated. Finally, Dante, your single comment about wanting to work hard just like me made this degree even more purposeful and worthwhile. Through the last several years, I hope my children see that they can also do hard things and accomplish anything they set their minds to.

Acknowledgment

I am deeply grateful for the support of my dissertation committee, Dr. Jamie Ball and Dr. Sandra Johnson. While research questions changed and evolved, my committee was there to help ensure methodology and alignment ensued. Thank you for your persistence and belief in my accomplishing of this culminating doctoral end-product.

I am also grateful for my family, friends, and colleagues' emotional, intellectual, and professional support. Finally, to my mom and Al for providing the financial foundations for college, which gave me that first spark and yearning to be a lifelong learner.

Table of Contents

List of Tables

Table

List of Figures

Figures

Chapter 1: Introduction

The United States reports acute shortages of teachers due to higher attrition rates and greater demand. Sutcher et al. (2019) postulated the importance of increasing the number of teachers in the workforce and keeping the effective ones. Nationally, math-related subjects show a teacher shortage in 47 states, while science subjects face the same in 43 states (Cross & Pollk, 2018). The teacher shortage was further compounded by attrition, influencing supply and demand. For example, in subject areas such as mathematics and science in California in the 2015–2016 school year, teacher turnover was higher, 19.1% and 18.5%, respectively, than other subject areas of 16.38% (Darling-Hammond et al., 2018). In the 2018–19 school year, 289,614 students were enrolled across 675 full-time virtual charter schools in the United States (US Department of Education, 2020).

Teacher self-efficacy is the belief that teachers can guide their students to success (Gallavan, 2017). There was limited information on teacher self-efficacy in the K–12 virtual charter setting. However, there was an increase in virtual charter schools and student enrollments consistently since the 2013–2014 school year (US Department of Education, 2020). The study was on teacher self-efficacy in virtual charter schools in the United States in the K–12 STEM subject areas. A significant factor in teachers' job satisfaction in the online setting was related to the school conditions (Borup & Stevens, 2017). Advancing the understanding of teacher self-efficacy in a virtual charter school may help influence professional development and provide opportunities that increase teachers’ self-efficacy may lower teacher attrition in the online setting. Teachers with higher self-efficacy have a more significant impact on student academic achievement, higher teacher retention, and a greater sense of job satisfaction (Chesnut & Burley, 2015; Demir, 2020; Larkin et al., 2018; Shahzad & Naureen, 2017).

This research study on teacher self-efficacy in the virtual setting covers the background, problem statement, purpose, significance, research questions, and hypothesis. The theoretical framework will follow and provide the context for the study. A list of terms with definitions, assumptions, scope, and delimitations is also covered.

Background of the Problem

Virtual charter schools in the United States are those in which the learning is fully remote, usually undertaken from a student's home. Additional instructional components and support are offered via virtual classrooms, video conferencing software, phone, or emails. As of 2019, there were 297,712 students in full-time virtual charter schools (Molnar et al., 2019). School choice is a driver of this additional education option for families. Families can choose an alternative to the local public school that their student is assigned. As such, charter schools are one of the fastest-growing options for school choice (Berends, 2021). Teaching self-efficacy research is minimal in the K–12 online setting, particularly science, technology, engineering, and math. Teaching online requires additional skills teachers may not have had in their teacher preparation programs. Teachers transitioning from face-to-face teaching to the online setting may bring their existing instructional practices and skills that have worked in the traditional environment. The literature review discusses teacher self-efficacy and online learning, pedagogy, and professional development that can apply to STEM subject teachers in virtual charter schools.

The North American Council of Online Learning offers course design, organization, and best practices for Online Learning. Organizations such as Quality Matters and Universal Design for Learning provide rubrics and checklists to support teachers in implementing content in the virtual setting. In addition, these organizations provide support on improving instruction for increasing inclusivity, accessibility, and engagement. Online pedagogy refers to teaching and instructional practices used over the internet, which may require new strategies for teachers. Technological, pedagogical, and content knowledge (TPACK) is a framework that includes the components of technological, pedagogical, and content knowledge as well as how the intersection supports online teaching and learning (Koehler & Mishra, 2009). The junction of pedagogy knowledge, content knowledge, and technological knowledge (TPACK) may provide a practical framework for teaching in the virtual charter school setting. Online learning and teaching emphasize student-centered learning with various active learning strategies in an asynchronous and synchronous environment (Chen et al., 2018). Web 2.0 applications are options for STEM subject areas to increase student-centered approach and engagement. These applications are technological tools that allow students to interact and create content with others. Virtual laboratories and simulations can also use the TPACK framework elements to provide a student-centered, collaborative, and engaging way to access and practice the learned content (Tanak, 2018).

The literature gap showed there was limited information on teacher self-efficacy in the online virtual charter school setting. Self-efficacy in online teaching may increase through theory and practice (Ofem et al., 2019). Professional development opportunities may be modeled after teacher preparation programs and provide learning growth to virtual teaching staff through onsite options or web-conferencing tools. Bandura (1997) proposed that mastery experiences, vicarious experiences, verbal persuasion, and emotional states help teachers achieve higher self-efficacy (Gallavan, 2017). The four sources which improve and strengthen self-efficacy may be offered as professional development at virtual charter schools.

Statement of the Problem

The problem is that there was little information in the literature on how teacher self-efficacy impacts STEM subject matter teaching beliefs in the online setting in virtual charter schools in the United States. The research was limited to teacher preparation programs and faculty in higher education. This study shares information about the K–12 virtual charter school context. The current problem is that there was minimal research about self-efficacy in the K–12 virtual setting in science, technology, engineering, and math subjects. The extent of the problem is national and affects most states with virtual charter schools. The research is relevant to all K–12 virtual charter schoolteachers in science, technology, engineering, and math subject areas in the United States. Educators' and students' impact may be prevalent due to limited research on teacher self-efficacy online. With the growth of distance education, research on self-efficacy was necessary for the K–12 virtual environment to increase teacher self-efficacy opportunities. A higher self-efficacy may correlate with higher job satisfaction, teacher retention, and improved student performance (Chesnut & Burley, 2015; Demir, 2020; Larkin et al., 2018; Shahzad & Naureen, 2017).

The importance of the problem is that teacher self-efficacy correlates positively to student learning and growth (Goddard et al., 2000). The background problem showed there were additional skill sets and standards to teaching in the online setting. Teachers who had little exposure to online teaching and learning in their teacher preparation program may use adaptations of face-to-face teaching practices (Moore-Adams et al., 2016). However, these adaptations were ineffective as not all skills transfer over into the online setting. Servant leaders in the online environment may provide professional development opportunities to strengthen skills, confidence, and even self-efficacy.

The literature gap revealed limited information on teacher self-efficacy in the online educational setting. This study filled the literature gap, providing a greater understanding of teachers' beliefs and attitudes on teaching and student outcome expectancy in STEM subjects. This research may help inform K–12 virtual charter schools in the United States about professional development needs inclusive to online STEM teachers.

Purpose of the Study

The purpose of this quantitative causal-comparative study was to test for statistically significant differences between teachers' self-efficacy and attitudes towards STEM across STEM subject areas and virtual teaching experience (0–2 years, 2–5 years, and more than five years) in the K–12 online setting. The target population was 92 full-time teachers in K–12 virtual charter schools in the United States teaching science, technology, engineering, and math. The study was necessary because there are many students in the online educational setting, and there was limited data about teacher self-efficacy, particularly in the STEM subject areas. If the study were not conducted, there would continue to be a lack of scholarly literature about teacher self-efficacy in the STEM subject areas in online education, possibly affecting job satisfaction, retention, and student achievement. In addition, the study contributed to the knowledge base by sharing research on teacher self-efficacy in the online setting, emphasizing the STEM subject areas.

The quantitative research was a non-experimental, causal–comparative research design to determine teacher efficacy in the virtual charter school environment. The statistical test was a two-way analysis of variance (ANOVA), comparing groups and testing for differences between dependent and independent variables. The Teacher Efficacy and Attitudes Toward STEM (T-STEM) survey measured teacher self-efficacy for teaching. It included teachers' beliefs that affect student learning, the frequency at which students use technology, and usage of STEM instructional practices, along with the teachers' attitudes towards 21st-century learning, attitudes towards teacher leadership, and their awareness of STEM careers (Friday Institute for Educational Innovation, 2012f). The dependent variable was the composite score of teacher self-efficacy and attitudes towards STEM present in the individual STEM subject areas in the virtual setting. The two independent variables were the STEM subject area in which the teacher works and the years of virtual teaching experience. The virtual teaching experience was categorical, indicating the number of years teachers had in the online setting.

The research objectives were to discover the teacher self-efficacy and attitudes toward STEM that were present, at the time of the study, in K–12 virtual charter schools. Additionally, an interaction effect compared the independent variables of STEM-specific subject areas and virtual teaching experience concerning self-efficacy. The research will be published to share with K–12 virtual charter school administrators and instructional leaders in order to inform relevant professional development opportunities. Additional professional development may enhance teacher self-efficacy and other factors such as job satisfaction, teacher retention, and student achievement in STEM subject areas in the online setting.

Significance of the Study

This research study advanced knowledge in the K–12 virtual charter school environment. It reduced the literature gap on teacher self-efficacy in science, technology, engineering, and math subject areas in the online setting. School administrators and instructional leaders may benefit from this research by informing the teachers' current levels in this setting with self-efficacy. Teachers may benefit from learning their current levels of teaching self-efficacy and attitudes towards STEM in the virtual charter school setting. Administrators and leaders can provide opportunities for professional development in various ways to increase teacher self-efficacy. Teachers with higher self-efficacy have higher job satisfaction, retention, and student achievement (Chesnut & Burley, 2015; Demir, 2020; Larkin et al., 2018; Shahzad & Naureen, 2017).

School choice and the benefits of online learning have created a demand for non-traditional school settings (Cooper et al., 2020). The study would change professional practice by proposing learning opportunities or certification programs that consider teacher self-efficacy and online education readiness in the online school. The implications for positive social change will be more effective learning environments where teachers can teach a diverse student population online.

Research Questions

The research questions determined statistical significance between subject matter and virtual teaching experience and scores on the Teacher Efficacy and Attitudes Toward STEM (T-STEM) survey. The statistical test utilized was a two-way analysis of variance (ANOVA), comparing groups and testing for differences between dependent and independent variables. The dependent variable was the teachers' teaching self-efficacy levels in their STEM subject area, while the independent variable was the STEM-specific subject areas and the teachers' virtual teaching experience levels. The research questions were as follows:

Research Question One: Does a statistically significant difference exist between the subject matter of science, technology, engineering, and math (STEM) in teacher efficacy and attitudes towards STEM, as measured by the T-STEM survey from teachers in virtual charter schools in the United States?

Research Question Two: Does a statistically significant difference exist between the virtual teaching experience, with categories (categories of 0–2 years, 2–5 years, and more than five years) and teacher self-efficacy and attitudes towards STEM scores, as measured by the T-STEM survey from teachers in virtual charter schools in the United States?

Research Question Three: Does a statistically significant interaction effect exist between subject matter (science, technology, engineering, and math) and virtual teaching experience (categories 0–2 years, 2–5 years, and more than five years) in virtual charter schools in the United States, in terms of teacher self-efficacy and attitudes towards STEM, as measured by T-STEM survey?

Hypotheses

Hypotheses for quantitative research are predictions about expected outcomes between the variables in the study (Creswell & Creswell, 2018). Null hypotheses were stated to show no statistical significance between variables. In order to determine if there is a statistical significance between teacher self-efficacy and attitudes towards STEM, the research questions were as follows:

$H1_o$: There is no statistically significant difference in mean composite teacher self-efficacy and attitudes toward STEM scores, as measured by the T-STEM survey, between teachers who teach STEM subjects (science, technology, engineering, and math) in a virtual charter school in the United States.

$H1_a$: There is a statistically significant difference in mean composite teacher self-efficacy and attitudes toward STEM scores, as measured by the T-STEM survey, between teachers who teach STEM subjects (science, technology, engineering, and math) in a virtual charter school in the United States.

$H2_o$: There is no statistically significant difference in mean composite teacher self-efficacy and attitudes toward STEM scores, as measured by the T-STEM survey, between teachers' virtual teaching experience (categories 0–2 years, 2–5 years, and more than five years) in a virtual charter school in the United States.

$H2_a$: There is a statistically significant difference in mean composite teacher self-efficacy and attitudes toward STEM scores, as measured by the T-STEM survey, between teachers' virtual teaching experience (categories 0–2 years, 2–5 years, and more than five years) in a virtual charter school in the United States.

$H3_o$: There is no statistically significant interaction effect between teachers who teach STEM subjects (science, technology, engineering, and math) and virtual teaching experience (categories 0–2 years, 2–5 years, and more than five years) in a virtual school in the United States in terms of teacher self-efficacy and attitudes toward STEM scores, as measured by the T-STEM survey.

$H3_a$: There is a statistically significant interaction effect between teachers who teach STEM subjects (science, technology, engineering, and math) and virtual teaching experience (categories 0–2 years, 2–5 years, and more than five years) in a virtual school in the United States in terms of teacher self-efficacy and attitudes toward STEM scores, as measured by the T-STEM survey.

Theoretical Framework

Self-efficacy theory and Servant Leadership Theory created the theoretical framework of this study. Self-efficacy theory is part of Albert Bandura's Social Cognitive Theory, which showed how individuals' perception of their performance to complete a task would affect their behavior and ability to succeed (Bandura, 1984). The choice to approach or avoid a task, the effort, persistence, thinking, decision-making, and emotional reactions may result from the individual's self-efficacy perceptions (Lippke, 2017). The higher self-efficacy an individual has for a task, the more they will initiate and attempt a challenging task.

There were four sources of self-efficacy to utilize as a target of intervention. An individual’s mastery experiences, vicarious experiences, verbal persuasion with others, and emotional arousal can create barriers and new opportunities for successful performances (Lippke, 2017). Teacher opportunities to observe peers’ modeling and observations provide mastery and vicarious experiences, building higher self-efficacy in teaching. Best practices and strategies can be offered by verbal persuasion by leaders, collaborations with peers, and even scholarly literature that guides the teacher with best practices. Lastly, emotional arousal, also called emotional state, may be improved with the teacher's subsequent positive performances.

Servant leadership theory, originated by Robert Greenleaf, is when a leader focuses on followers first (Greenleaf, 1973). The leadership philosophy is about serving and empowering others. A servant leader may be an administrator or an instructional coach in a school setting who thinks about others first and is committed to their professional growth (Spears, 2010). As a servant leader, organizational change and improvement are essential, but this occurs through the people and their individual goals. A servant leader ensures that teachers have what they need to succeed in their environment. Self-efficacy may be strengthened by a leader offering the teacher the opportunity to observe and collaborate with other teachers at the school site.

The study focused on the intersection of self-efficacy theory and servant leadership theory, where learning and growth opportunities can be made available for teachers. Leaders may create opportunities to offer professional development for their science, technology, engineering, and math teachers in the K–12 virtual charter school setting. For a leader to understand their staff's needs, research questions will share if there was a significant difference and interaction among these independent variables—STEM subject matter and years of virtual teaching experience. The data analysis determined if there was a statistically significant difference between teacher efficacy in science, technology, engineering, and math subjects compared to the dependent variable of subject and years of experience.

Definition of Terms

The definition of terms includes key terms used in this research study. The definitions will exclude common terms related to teacher self-efficacy and servant leadership. The following terms were central to the study:

Emotional States (Arousal). Various physiological states provide information to individuals that may influence perceived self-efficacy (Bandura, 1977).

Mastery Experiences. A source of information comes from performance accomplishments that may affect an individual's perceived self-efficacy (Bandura, 1977).

Pedagogy. The art and science of teaching using various teaching strategies to improve learning outcomes (Bhowmik et al., 2013).

Professional Development. Opportunities for teacher support in pedagogy, integrating technology, and digital competencies for a context such as the online setting (Adnan, 2018).

Science, Technology, Engineering, and Math (STEM) Subjects. This study's independent variable includes the curriculum subject areas of science, technology, engineering, and math (Kennedy & Odell, 2014).

Self-efficacy Theory. A theory that posits an individual's perceptions of their capabilities is a crucial determinant of successful outcomes and may be strengthened by opportunities such as mastery experiences, vicarious experiences, verbal persuasion, and emotional states (Gallagher, 2012).

Servant Leadership. A form of leadership where serving others comes first (Greenleaf, 1973).

Social Cognitive Theory. An individual's social environment impacts motivation, learning, and self-regulation (Schunk & DiBenedetto, 2020).

Teacher Self-Efficacy. A teacher's belief in their ability to plan, organize and accomplish instructional activities to meet educational expectations and goals (Skaalvik & Skaalvik, 2016).

Technological Pedagogical and Content Knowledge (TPACK). The intersection of technological, pedagogical, and content knowledge is needed for effective technology instruction (Koehler & Mishra, 2009).

Teacher Efficacy and Attitudes Toward STEM (T-STEM) Survey. The Friday Institute for Educational Innovation developed an instrument with 63 self-assessment questions to measure changes in teachers' confidence and self-efficacy in STEM subject content and teaching, the use of technology in the classroom, 21st-century learning skills, leadership attitudes, and STEM career awareness (Friday Institute for Educational Innovation, 2012f).

Verbal Persuasion. A source of information comes from suggestions affecting an individual's perceived self-efficacy (Bandura, 1977).

Vicarious Experiences. A source of information from observing others' performances that can affect an individual's perceived self-efficacy (Bandura, 1977).

Virtual Teaching Experience. An independent variable used in the study shared the amount of time a teacher has been teaching online courses (Moore-Adams et al., 2016).

Web 2.0 Tools. The technology and tools which enable users to disseminate knowledge and content, interact and collaborate with peers, and share data over the Internet (Alhassan, 2017).

Assumptions

The study on teacher self-efficacy in the K–12 virtual charter school environment had some assumptions. The first assumption was that participants completed the T-STEM survey honestly and truthfully (Verma & Abdel-Salam, 2019). The questionnaire's clarity was increased by providing clear and concise directions and wording. The survey recruited participants using non-probability sampling methods of purposive and snowball sampling. Snowball sampling helps exploratory research and hard-to-reach participants (Biernacki & Waldorf, 1981). The recruitment of participants was by purposive sampling through social media channels, Facebook groups, and an advertisement on Facebook and LinkedIn. Participants were selectively recruited based on teaching, online schooling, or STEM education interests. A survey link was made available at the completion of the research survey for additional snowball sampling of teachers. Social media channels related to virtual charter schools, such as Facebook groups, increased the diversity and sample size. Inclusion and exclusion criteria were included in the survey to include only eligible targeted participants (Fink, 2003). The survey consisted of exclusion and inclusion criteria to ensure participation from K–12 teachers in science, technology, engineering, and math subject areas within virtual charter schools.

Two-way ANOVA statistical testing assumed that the data were continuous, but the independent variables used in this study were categorical: STEM subject areas and years of virtual teaching experience. The dependent variable, the mean composite scores on the T-STEM survey, was treated as a continuous variable to utilize two-way ANOVA testing. Norman (2010) stated that Likert survey data could use ANOVA testing due to the test robustness, even though ordinal and this test requires continuous data. The Likert survey results and the categorical data were run through the two-way ANOVA test. ANOVA testing was appropriate over non-parametric testing since it can overcome small sample sizes, data that is not normally distributed, and inequality of variances while providing similar power when there are violations to the assumptions for using the test (de Winter & Dodou, 2010; Norman, 2010). The generalizability of this study applies only to the current case of teachers that participated in this research study. Non-random probability sampling creates potential bias and limits generalizability (Taherdoost, 2016). This study was exploratory for the virtual charter school setting, and the research may be repeated for additional generalizability beyond the context of this study.

Scope and Delimitations

This study's coverage focused on the self-efficacy of virtual charter schoolteachers in the United States. The results of this study should be considered in terms of the assumptions, limitations, and delimitations. A delimitation of the research was any K–12 virtual charter schoolteacher in the United States who teaches science, technology, engineering, and math subjects. The delimitations set the boundaries and scope of the research set within this study appropriate for the available resources, accessibility to virtual teachers, and time constraints (Theofanidis & Fountouki, 2018). The study does not intend to cover teachers outside STEM subject areas or teachers in the traditional face-to-face setting. Many virtual charter schools are K–12, combining elementary and secondary levels, with 419 out of the collective 675 virtual charters spanning these grade levels (US Department of Education, 2020). The scope provided a larger sample size with K–12 STEM teachers' selection to increase the statistical data's effect size to 0.4 and a power of 0.80.

Limitations

Limitations were present in research studies with threats to internal and external validity (Price & Murnan, 2004). Internal validity limitations were a lack of random sampling and the inability to manipulate the independent variable. The sampling method was a non-probability snowball and purposed sampling method, focusing on social connections and shared social media sites such as LinkedIn. The independent variable cannot be manipulated because participants were already exposed to teaching in the STEM subject area and virtual teaching experience before participating in the survey. Confounding variables were demographic and personal attributes that may affect the dependent variable and explain additional factors in the relationship between the independent and dependent variables (Creswell & Creswell, 2018). The confounding variable was online teaching preparation programs and any professional development teachers have previously taken in advance of this study. Personal factors such as cognitive, affective, biological factors and environmental factors such as genetics, and influences of culture, social support, or situational characteristics may also affect teachers' self-efficacy levels (Burke et al., 2009).

External validity is the research's validity being generalizable and repeatable in other populations, settings, and measures (Creswell & Creswell, 2018). The three threats to external validity were the limitation of generalizability beyond the groups tested, the school setting, and the time it took to complete the survey. Limitations in exploratory studies cannot be conclusive until results are repeated (Queirós et al., 2017). Generalizability applies to participants willing to participate in a survey study, with a possible causal relationship for teachers in the K–12 virtual charter schools in the United States, specifically in the science, technology, engineering, and math subjects. There were limitations in generalization to the larger population when using convenience sampling methods, such as purposive and snowball sampling. There is a higher likelihood of bias resulting from frame coverage, selection bias, size bias, and nonresponse bias, resulting in data that may not represent the larger population (Fricker, 2008). Finally, causal-comparative research designs can only determine the possible cause-and-effect relationships of the independent variable affecting the dependent variable (Salkind, 2010). Reversal causation is also a potential weakness of causal-comparative designs. The cause-and-effect relationships may be from self-efficacy affecting both teacher STEM-specific subject area teaching and virtual teaching experience years, or vice versa (Salkind, 2010).

The study included survey limitations due to the participants' perceived time constraints, resulting in hurried responses or non-participation. The study also had finite response categories compared to an interview where respondents can have a range of responses. Self-reported data were also a limitation and cannot verify for exaggeration or underestimation of teachers' perceived self-efficacy.

The steps to minimize methodological limitations were to compare homogeneous subgroups (Salkind, 2010). The data analysis categorized STEM-specific subject teachers to their subject area and then teachers with similar categorical virtual teaching experience to their levels. The research divided the STEM subject area and virtual teaching experience into two research questions to determine a significant difference between each independent variable and the dependent variable's self-efficacy and attitudes towards STEM scores. The demographic questions were asked at the start of the survey to control for the independent variables. A two-way ANOVA statistical test inferred a significant difference between the independent and independent variables.

Chapter Summary

The study highlighted the need for research regarding STEM teachers' self-efficacy in K–12 virtual charter school settings. Distance education is growing, and teacher turnover is higher in science and math subjects (Darling-Hammond et al., 2018; US Department of Education, 2020). There was limited research on best practices in the virtual teaching environment, with a significant amount of literature on teacher preparation programs and higher education. The study provided information on teachers' perceived self-efficacy in elementary, science, technology, engineering, and math subject matter in virtual charter schools. Leaders may use this information to provide professional development opportunities, which may increase self-efficacy in the online setting. The following section reviewed current literature related to teacher self-efficacy.

Chapter 2: Literature Review

This study shared the degree of teacher self-efficacy and teachers' perceived expectancy of teaching outcomes, in the science, technology, engineering, and math (STEM) subjects, in virtual charter schools in the United States. Leaders can utilize the research data to provide professional development opportunities for their teachers to encourage teaching self-efficacy in STEM subjects. The problem is that there was little information in the literature on teacher self-efficacy in STEM subjects in virtual charter schools. This study aimed to determine the degree of teaching self-efficacy in STEM subjects in virtual charter schools in the United States. Leadership can utilize this information to determine any professional development needs of their teaching staff. The current literature review provided insight into teacher self-efficacy topics related to STEM subject teaching, online education, and professional development. The study focused on the benefits of teacher self-efficacy, online pedagogy, and teacher professional development based on the self-efficacy theory and Servant leadership theory.

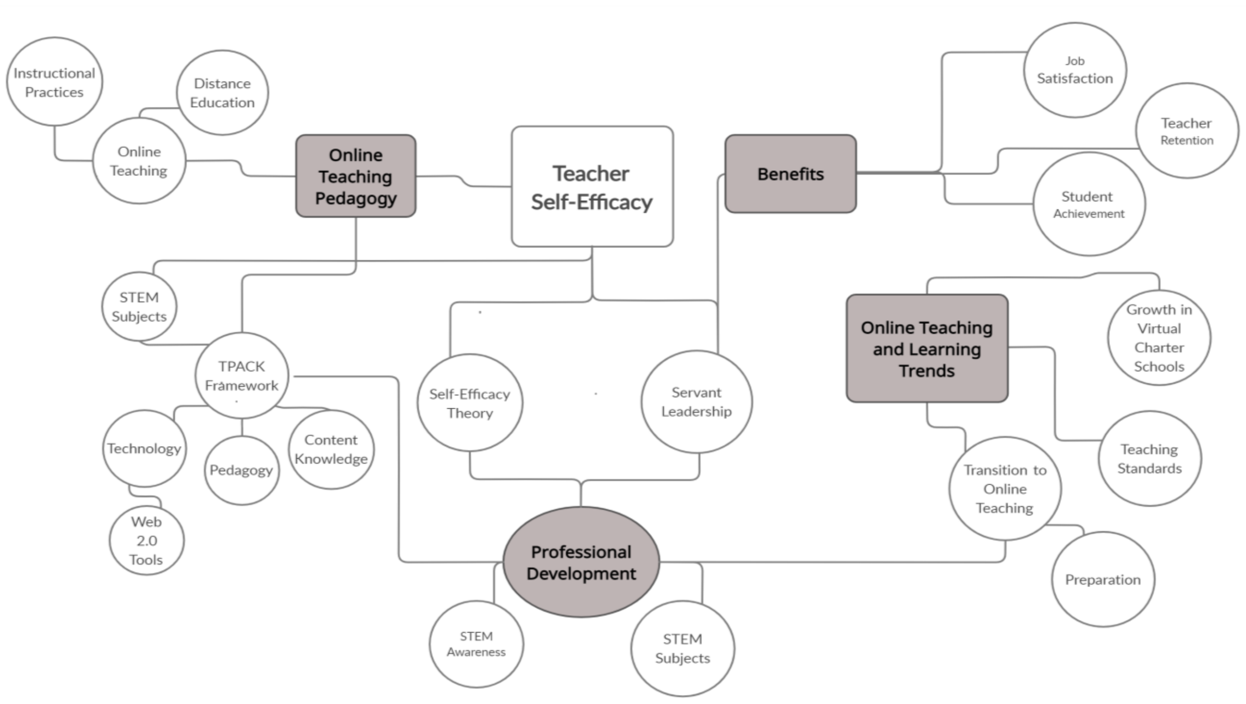
This literature review provides insight and background information for this study on teacher self-efficacy in the STEM subjects in virtual charter schools in the United States. The literature review includes the literature search strategy and the theoretical framework. Next was the research literature review presenting information on the benefits of self-efficacy, online pedagogy, and professional development. Lastly, the literature review finishes with the contrary literature on low teacher self-efficacy and the need for more professional development. This chapter concluded with the need for this research and a summary.

Literature Search Strategy

The literature search strategy originated from keywords and concepts related to teacher self-efficacy. The keywords and phrases included *self-efficacy theory*, servant leadership, *online* *teaching, charter school, professional development, pedagogy, technology, STEM subjects*, and *technological pedagogical content knowledge* (TPACK). *Figure 1* illustrates the keywords and phrases used in the literature search strategy.

Figure 1

Key Words and Concepts for Literature Search Strategy



Note. Illustration of keywords and concepts in the literature search strategy.

The American College of Education Library database served as the primary source for searching keywords and phrases in this literature review. EBSCO Discovery Services, ResearchGate, SAGE Publishing, Google Scholar, and Scopus were used for finding scholarly journal articles. The United States Department of Education provided statistics, information on charter schools, and teaching requirements to provide background context. The literature and research studies were selected based on the relevance to teaching self-efficacy and professional development for online education. The literature included resources from various countries in traditional K–12 grades and online settings, including studies with pre-service teachers in graduate programs.

Sources provided insight into the research topic of teaching self-efficacy in the online environment. The research was limited to the K–12 online setting, but studies in higher education and teacher preparation programs have been conducted. The literature showed a link between teaching self-efficacy, job satisfaction, retention, student achievement, and professional development in the online setting. The literature review also investigated professional development opportunities available in face-to-face and online environments. Servant leadership may act as a model for increasing professional development opportunities in online charter schools, impacting teacher self-efficacy in the science, technology, engineering, and math subjects. An increase in self-efficacy may positively correlate to job satisfaction, retention, and student achievement.

Theoretical Framework

Self-efficacy theory and Servant leadership theory provided the theoretical basis for this study. Together, these two theories provided the intersection of leadership which empowers and commits to teachers' professional growth while also creating a culture that may increase teacher self-efficacy in the online setting. The theoretical framework guides this research study's methodology, design, data analysis, and conclusions (Adom et al., 2018). The findings may help guide leaders to support and provide opportunities to strengthen their teachers' self-efficacy, resulting in higher job satisfaction, retention, and student achievement in secondary teachers in science, technology, engineering, and math courses.

Self-efficacy Theory

Self-efficacy is an internal thought control of actions through cognitive and behavioral factors, determining how a person feels, thinks, and acts (Schwarzer & Hallum, 2008). Albert Bandura theorized Self--efficacy theory (SET) as part of a social cognitive theory that comes from mastery experiences, vicarious experiences, verbal persuasion, and emotional and physiological states (Bandura, 1997, p. 89). Self-efficacy can apply to teacher self-efficacy. The perceived self-efficacy beliefs guide choices, effort, perseverance, resilience, and accomplishments a person goes forth with (Bandura, 1997, p. 3). Teaching self-efficacy correlates to job satisfaction, job retention, and higher student achievement, which was evident in the literature (Chesnut & Burley, 2015; Demir, 2020; Larkin et al., 2018; Shahzad & Naureen, 2017).

Understanding and implementing the dimensions of self-efficacy theory supported the increase in teacher self-efficacy in the STEM subjects in the virtual charter school by highlighting teacher beliefs that may need additional professional development. Research stated that struggling teachers may not have had enough opportunities to produce positive outcomes (Gallagher, 2012). Leadership can provide struggling teachers professional development and support to increase positive outcomes. Mastery experiences and vicarious experiences are the two most influential factors in developing an individuals' self-efficacy (Barton & Dexter, 2020; McKim & Velez, 2016). More so, the focus of leadership may be providing the conditions necessary for teachers to have opportunities that increase their self-efficacy and STEM integration into the online setting. This study's research results informed school leaders of the composite scores for self-efficacy and attitudes towards STEM in and across science, technology, engineering, and math subjects in virtual charter schools in the United States. The research supported the questions because the results inform any professional development needs for online schools to increase teacher self-efficacy in STEM subjects.

Teacher Self-efficacy and Job Satisfaction

Teacher self-efficacy correlates positively with job satisfaction (Demir, 2020; Skaalvik & Skaalvik, 2014; Türkoğlu et al., 2017), and quantitative survey research has provided evidence on the positive relationship between the two. Quantitative studies from 2,569 elementary and middle school teachers showed a moderate positive correlation of teacher self-efficacy with job satisfaction (Skaalvik & Skaalvik, 2014). Another quantitative analysis from Demir (2020) concluded that 321 middle school teachers show that their teachers' self-efficacy beliefs correlate to job satisfaction. The instruments used in the surveys were valid and reliable, with a Cronbach's Alpha of 0.787 for Demir (2020) and a Cronbach's Alpha of 0.93 from Skaalvik and Skaalvik's (2014) research.

A meta-analysis study found similar positive relationship results between teacher self-efficacy and job satisfaction. An international meta-analysis from Kasalak and Dağyar (2020) included a large sample size of 150 studies across 50 countries, with 426,515 reported teachers showing a significant, positive correlation of teacher self-efficacy with job satisfaction. One limitation of the meta-analysis was that it did not include studies from the United States. Türkoğlu et al. (2017) suggested that organizations prioritize practices to improve teachers' perceptions of self-efficacy. Leadership in an online virtual charter school environment may provide opportunities to strengthen teacher self-efficacy. The benefits of giving time for professional growth and support may increase teaching self-efficacy with a positive correlation of other downstream effects of job satisfaction, job retention, and increased student achievement (Chesnut & Burley, 2015; Demir, 2020; Larkin et al., 2018; Shahzad & Naureen, 2017).

Teacher Self-efficacy and Job Retention

Teacher retention in a K–12 educational setting may have a relationship to teacher self-efficacy. A teacher's beliefs positively affect organizational commitment (Demir, 2020). Earlier research from Kreitner and Kinicki (2009) showed that employees' commitment to an organization correlates positively to a higher level of positive job-related attitudes and behaviors (Demir, 2020). Recent studies have linked variables to teacher attrition, such as a positive relationship of self-efficacy and having a mentor, to a lower attrition rate for teachers with less than five years of experience (Renbarger & Davis, 2019). In another study by Skaalvik and Skaalvik (2016), "Teacher Emotions in Primary and Secondary Education: Effects of Self-Efficacy and Collective-Efficacy, and Problem-Solving Appraisal as a Moderating Mechanism," 523 secondary teachers completed a questionnaire concerning seven stressors in teaching. The findings found that teacher self-efficacy negatively correlates to value conflict, low student motivation, and a lack of supervisory support and trust, which motivated teachers to leave the profession (Skaalvik & Skaalvik, 2016).

The positive effects of increasing teacher self-efficacy on job satisfaction negatively impact retention when teachers have lower self-efficacy. Leadership, including more supervisory support, may increase teachers' self-efficacy. Larkin et al. (2018) posited that having professional development and a mentor increases the likelihood of retention in the virtual setting for the first five years. An earlier study on the latent self-efficacy factor of job stress predicts stress and teacher burnout (Schwarzer & Hallum, 2008). Leaders may help prevent burnout, increase retention, and self-efficacy by providing additional support and professional development opportunities for teachers experiencing job stress.

Teacher Self-efficacy and Student Achievement

A teacher's abilities and confidence in their content increase students' achievement. Interviews with a small elementary teacher population showed that student learning and higher achievement were connected to teacher self-efficacy and content knowledge (Gonzalez & Maxwell, 2018). The research appears to follow the same results for secondary teachers, with positive self-efficacy perceptions leading to increased student achievement (Shahzad & Naureen, 2017). Bal-Taştan et al. (2018) showed this relationship between student achievement and efficacy to secondary science education, with the highest correlation to instructional strategies.

Servant Leadership Theory

Along with Bandura's self-efficacy theory, Greenleaf's servant leadership theory explains how leaders focus on their followers' needs (Greenleaf, 1973). Servant leadership, originated by Robert Greenleaf, proposed that a leader is a servant first, focusing on their followers (Greenleaf, 1973, p. 15). Larry Spears created ten traits that took the ideas of Greenleaf's principles of servant leadership. In the context of this research, the principle that applies to a servant leader is the commitment to the professional growth of people (Spears, 2010). Studies have shown that stress leads to emotional exhaustion; stress was a factor in attrition, having a weaker correlation in teachers who perceive their leadership through servant leadership (Wu et al., 2020). Servant leadership theory can be applied to virtual charter schools by providing professional development for individual teachers and collectively as an organization, based on low teacher self-efficacy and teaching outcome expectancy beliefs.

Servant Leadership and Teacher Job Satisfaction

The research was minimal on servant leadership and job satisfaction in education in the United States. Studies in Pakistan have indicated increases in job satisfaction when leaders practice servant leadership (Afaq et al., 2017). Internal job satisfaction showed a statistically significant relationship with what teachers perceived as servant leadership from their principals, with the highest correlations in stewardship and empowerment (von Fischer & de Jong, 2017). Additionally, teacher gender, degrees, years in education, school size, and working length with the same principal showed no statistically significant relationship with job satisfaction (von Fischer & de Jong, 2017).

Servant Leadership and Professional Development

Leaders advocate for their colleagues and student learning in education through stewardship and commitment to individuals' growth (Crippen & Willows, 2019). Leaders may provide opportunities for professional learning in the online setting through professional development. Reducing professional development barriers is statistically significant to higher job satisfaction in newer teachers with less than five years of teaching experience (Renbarger & Davis, 2019). Any teacher new to online learning may benefit from professional development because teacher preparation programs may have provided minimal support in the online setting.

This research informed school leaders of teachers' self-efficacy levels in secondary science, technology, engineering, and math subjects in virtual charter schools located in the United States. Using Bandura's primary sources of self-efficacy and servant leadership principles, a leader may determine how to help support teachers with lower self-efficacy, specifically by providing professional development opportunities. The research supported the questions because the data can determine if virtual teaching experience and STEM subject areas impact self-efficacy online. As a result, leaders may create a positive school culture that focuses on a solution-based approach (Polatcan, 2020).

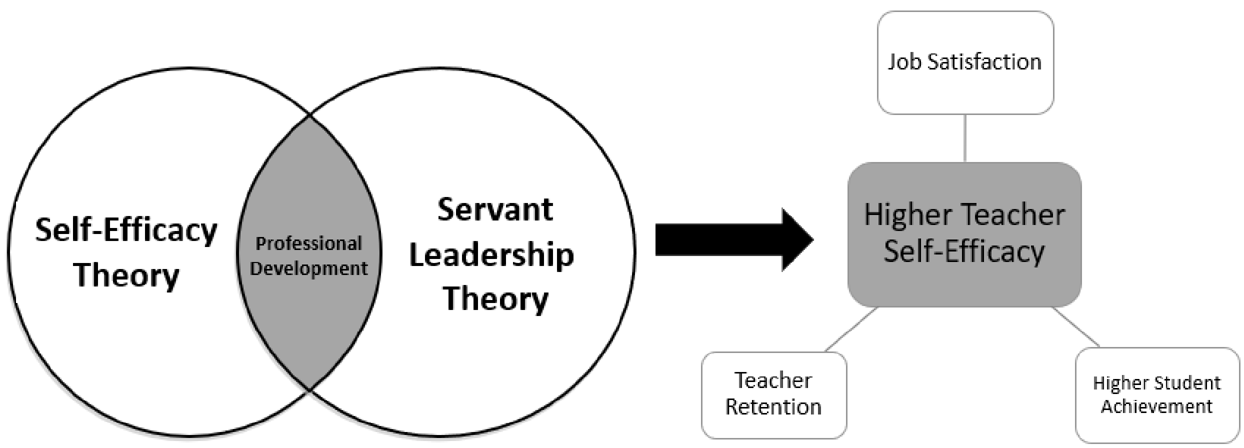
Leaders in virtual charter schools may use the T-STEM survey results to determine the professional development needs for STEM-subject area teachers in the online school setting. This research was necessary as many teachers transition from a face-to-face, brick-and-mortar setting to an online teaching environment. As a result, teachers may miss the confidence that may come with the high teaching self-efficacy they may have had in their previous traditional setting (Kaden, 2020). This study informed leaders about teacher self-efficacy from online virtual charter schools in the United States and any significant difference between STEM subjects and virtual teaching experience.

The dimensions of servant leadership and the Self--efficacy theory supported the study's purpose by sharing how leaders in an online setting can enhance teacher self-efficacy and expectancy in student outcomes. With servant leadership, leaders can offer more opportunities for professional development, which may increase job satisfaction, teacher retention, and the teacher's impact on student achievement (Kim & Seo, 2018; Schwarzer & Hallum, 2008). The research highlighted the areas of need, revealing teachers' self-efficacy beliefs through statistical analysis. In addition, the research results provided insight into professional development opportunities through various experiences, such as mastery and vicarious experiences, to increase the teachers' self-efficacy in STEM subjects in an online charter school environment.

As shown in Figure 2, the intersection of Self--efficacy theory and Servant leadership theory provides the intersection where a leader can support teachers' self-efficacy. A supportive school culture with a servant-leader reduces alienation, increases job satisfaction, and provides a solutions-based approach to challenges (Polatcan, 2020). Several research studies asserting the Self--efficacy theory positively correlated to aspects that promote job satisfaction, commitment to teaching, and higher student achievement (Chesnut & Burley, 2015; Demir, 2020; Larkin et al., 2018; Shahzad & Naureen, 2017). This study investigated a statistical significance between teacher self-efficacy, virtual teaching experience, and science, technology, engineering, and math subjects in the online teaching setting.

Figure 2

Theoretical Framework



Note. The intersection between teaching self-efficacy in science, technology, engineering, and math subjects and servant leadership is the opportunity for professional development.

Research Literature Review

A scholarly literature review indicated growth in online learning and teaching and a need for professional development in the online setting. The literature review informed how online teaching growth, best practices, and additional support were essential for K–12 teachers in the virtual charter school setting. Specific areas include online learning and teaching, pedagogy and instructional practices, online teaching and professional development, and self-efficacy theory and professional development implementations (Corry & Stella, 2018; Esani, 2010; Gloria & Uttal, 2020; Kaden, 2020; Lin & Zheng, 2015; Moore-Adams et al., 2016).

Online Learning Growth and Teaching Trends

Distance learning has become increasingly popular as an option for schooling in the last two decades. The National Education Policy Center published data on the scope and growth of virtual charter schools, including blended learning schools which use online teaching. As of 2019, 39 states have schools with 501 full-time virtual charter schools with 297,712 students (Molnar et al., 2019). Molnar et al. (2019) shared that the presence of charter schools has grown, with nearly 46.5% of virtual charter schools being a charter. However, the increase in distance education was not equitable across the different states. Epple et al. (2016) stated that seven states account for 61% of the charter school enrollments nationally, with California comprising 20% of the charter school population). The United States had 3,010,287 charter school enrollments in the 2016–2017 school year, while California charter school enrollment was 602,837 students (Wang et al., 2019). While the virtual charter school population was smaller nationally, at 212,311 students, it has increased significantly from 477 students in 2013–2014. With the increase in students in the virtual setting, teachers need to teach effectively online.

School choice is an option for parents/guardians to enroll their students in popular options of public, private, charter schools, or homeschool. Some families choose virtual charter schools because education may be a more personalized experience with expanded curricular options, school safety concerns, and flexible schedules funded with public tax dollars (Beck et al., 2016; Bergman & McFarlin, 2018; Marsh et al., 2009). School choice is an option during environmental and health crises, where remote learning was prevalent. In 2020, during the surge of COVID-19, many school districts had offered a full-time virtual option (Gross et al., 2020).

The advantages and disadvantages of the virtual charter school option for K–12 students. The benefits include expanded curricular options, less printed materials needed, multiple modalities of collaboration, interactive materials, personalized learning, and flexible timing for migratory families and students with disabilities or at risk of dropping out of school (Cooper et al., 2020). However, virtual charter school education has seen challenges with student performance, as seen with lower performance occurring for state testing and graduation rates, with a graduation rate of 50.1% in virtual charter schools compared to 84% for the national average (Molnar et al., 2019).

There was minimal research to determine the cause of low performance in virtual charter schools. Smaller studies of student performance in charter schools exist in the literature (Chingos & West, 2015; Clark et al., 2015). Chingos and West (2015) asserted that middle school charter schools with virtual charter schools have higher negative performance for both math and reading when compared to non-virtual charter schools. The study showed charter schools were behind in performance compared to traditional public schools.

The Transition from Face to Face to Online Teaching

With the growth of online learning in 39 states, many teachers now teach virtually (Molnar et al., 2019). The COVID-19 pandemic in 2020 has resulted in school closures which have accelerated the number of educators teaching in the remote setting (Kaden, 2020). Due to the pandemic, the literature from remote K–12 teachers provided insight regarding newer teachers in the virtual education environment. Kaden's (2020) qualitative research postulated that teachers were not prepared to provide online instruction because of additional time to plan instruction and give feedback to students. If the preparation or professional development is limited for online teaching, any teacher instructing in the virtual setting may have gaps in the transference of pedagogy and best practices.

Online teaching requires greater planning and fostering of a social presence, including being a course designer, manager, webpage designer, coach, and resource manager (Esani, 2010; Gloria & Uttal, 2020). Course designing and organization are skills required by online teachers. However, time management was another essential element since students can access the course and submit work 24 hours a day (Cross & Pollk, 2018). Studies have shown various skills and proficiencies for teaching in the online setting beyond a traditional public-school teacher's scope.

Studies of online teachers reveal some overlap in the skills needed to teach in traditional settings and online (Beck & Beasley, 2020; Gloria & Uttal, 2020). Beck and Beasley (2020) showed that over 92 K–12 virtual schoolteachers had a beginning level for differentiation, assessment, curriculum, and strategies in the online setting. The proficiency scale ranged from novice, apprentice, practitioner, and expert. Beyond instructional planning, more considerations and skills were needed for the online setting, including synchronous instruction, lecture structure, instructor presence, learning objectives, course assessment, and utilizing the Learning Management System (LMS) as a teaching tool (Gloria & Uttal, 2020). Both pedagogy and technological knowledge were essential skills for the online setting. From these two studies, it was found that some skills were unique to the online teaching environment.

In the United States, teaching in a charter school varies by state requirements. For example, in California, the requirements to teach in a charter school are to have a bachelor's degree, hold a teaching credential or equivalency, and demonstrate subject matter competence by the Commission on Teacher Credentialing (Commission on Teacher Credentialing, 2017). If the teacher preparation program did not include the skills needed to teach in the online setting, there would be a knowledge gap and possibly a lower teaching self-efficacy. Gardner et al. (2019) researched the effect of 50 hours of professional development for 6–12th-grade math and science teachers on self-efficacy. Researchers used the same instrument from Friday Institute, the T-STEM survey utilized in this research. Due to professional development, the results showed increased math teaching self-efficacy, teaching outcome expectancy, and STEM career awareness (Gardner et al., 2019).

Online Teaching Standards

Teaching standards for online course design and teaching shared best practices with instructional designers and instructors (International Association for K–12 Online Learning, 2011a, 2011b; Quality Matters, 2020). Aurora Institute, previously International Association for K–12 Online Learning, iNACOL, has National Standards for Quality Online Teaching and National Standards for Quality Online Courses. The National Standards for Quality Online Teaching include 11standards which help guide professional development and evaluation of online teaching (International Association for K–12 Online Learning, 2011a). Research from Cavanaugh and Roe (2019) and Adelstein and Barbour (2016) showed the rise in using standards to support online teaching and course setup. Cavanaugh and Roe's (2019) study across ten virtual secondary schools in Australia showed standard A, structures and concepts for effective online instruction, and standard B. Using technology in the online setting was the lowest-ranked among teacher ratings. Teachers were given eight days of onsite training over 12 months on online instruction topics, with results showing that all standards had increased in self-reported ratings. Standard A and B, alongside standard K for arranging media, were the most ranked change (Cavanaugh & Roe, 2019). This study showed that there could be growth in proficiency through professional development. Additional standards are available to support virtual teachers in course design and instructional planning.

Developing online courses improves the learning experiences for students. The National Standards for Quality Online Courses add standards and rubrics for five areas: content, instructional design, assessment, technology, and course evaluation and support (International Association for K–12 Online Learning, 2011b). Adelstein and Barbour (2016) determined each of the five sections' validity in the standards. While there were foundational standards and best practices in the literature, the standards were not comprehensive to an online environment's entire experience. Considerations such as student motivation and metrics to identify motivational criteria were lacking (Adelstein & Barbour, 2016). The combined conclusions from Cavanaugh and Roe (2019) and Adelstein and Barbour (2016) indicate the value of using the standards. More so, utilizing more than a set of standards may provide more thorough guidelines and counter any limitations from any one set of standards. The review of standards may provide professional development opportunities for virtual charter teachers.

National Standards for Quality have updated Online Teaching and Online Courses and instated a committee that has updated the National Standards set by iNACOL. The standards include professional responsibilities, digital pedagogy, community building, learner engagement, digital citizenship, diverse instruction, assessment, and instructional design, including explanations and examples (National Standards for Quality Online Learning, 2019a, 2019b). In addition, Quality Matters has guidance for K–12 standards in rubrics for online course design, continuing education, and online instructor skillset (Quality Matters, 2020). Teachers may consider using various resources to evaluate a course in the online environment which considers all course design elements, online teaching, and engagement. Lynch and Gaston (2020) compared 891-course completion grades for undergraduate students in either Quality Matters re-designed courses or the standard non-Quality Matter courses to determine if the redesigned courses entailed greater success and engagement. The evidence showed that final course grades were higher in the redesigned courses but no significant difference. Although there was no significant difference in performance, student evaluations showed a higher perception of success as the responses were higher in the redesigned Quality Matters redesigned courses (Lynch & Gaston, 2020). Using National Standards for Quality Online Learning standards for teaching and online courses and Quality Matters rubrics, the potential for higher grades and increased satisfaction through course design may be possible. Further research is needed to determine the results in the K–12 setting.

Universal Design for Learning (UDL) is a set of guidelines that increases accessibility and inclusivity. UDL provides ways to minimize barriers, improve accessibility, and motivate students using various resources and modalities (Dalton, 2017). It has standards for course design and instructional practices, which provide a framework for teaching and evaluation (Meyer et al., 2014). According to Rice (2018) and Baldwin and Ching (2019), teachers can adapt the UDL principles for online courses. Rice (2018) postulated an online course designer that uses UDL principles, accessibility standards, and personalization to develop courses. Baldwin and Ching (2019) add to the usage of UDL principles by combining the guidelines into a checklist to use as an evaluation of personalization and accessibility. When working with diverse student populations, the need for increased representation, student expression, and various engagement techniques makes the content more attainable. Chen et al. (2018) received results from 1,767 valid students' responses in STEM courses and found that many shared UDL principles, which increased inclusive and engaging courses. Providing virtual teachers opportunities to practice UDL principles may support engagement, accessibility, and inclusivity during online coursework.

Online Pedagogy and Instructional Practices

Pedagogy for online courses differs from traditional face-to-face instruction (Esani, 2010; Gloria & Uttal, 2020). Teachers may require opportunities for professional development to help support efficacy in the online setting. Technological, pedagogical, and content knowledge (TPACK) elements may be incorporated into online courses to increase interaction and engagement (Chen et al., 2018). Using Web 2.0 tools may help support STEM subject area online teaching in online environments.

Teaching and Self-efficacy

Self-efficacy is a belief that resonates with the teaching profession and impacts teaching behaviors, the performance level of students, and job satisfaction (Bal-Taştan et al., 2018; Renbarger & Davis, 2019). One of the focuses of schools is to provide the skills and standards needed to prepare students for college and careers. Teacher self-efficacy has been shown to link student performance in the literature; however, it has negligible effect. Studies show the positive correlation of teachers' self-efficacy on student performance (Kim & Seo, 2018; Shahzad & Naureen, 2017). Kim and Seo (2018) postulated in their meta-analysis study with 4,130 teachers that teacher efficacy influences student achievement, but the effect size was small. There was a relationship to other factors, including the years of teaching experience. Shahzad and Naureen (2017) concluded that for 60 secondary teachers, teacher self-efficacy significantly impacts student achievement. Shahzad and Naureen's (2017) study had limitations of a smaller sample and was limited to Pakistan teachers. The sample size limitation could be attributed to the increase in achievement due to other factors beyond the teachers' self-efficacy.

The literature on teacher self-efficacy is limited regarding online teaching and focuses mainly on post-secondary distance education research. Previous studies show that most online teachers adapted their best practices from earlier experiences in face-to-face teaching, but without modification, which may prevent many strategies from being confidently transferred over into the online setting (Horovitz & Weisberg, 2014; Moore-Adams et al., 2016). Another study revealed that teachers with more web experience had higher self-efficacy as findings suggest that online teachers perceive the majority of their role as managerial and social (Corry & Stella, 2018; Lin & Zheng, 2015). The teachers desired more professional development in online teaching. The need to learn effective instructional practices and manage courses online was evident in current students from teachers in virtual settings (Corry & Stella, 2018; Lin & Zheng, 2015; Moore-Adams et al., 2016).

Harper (2018) posited that technology usage in the online environment increases collaboration and interactions among teachers and students and maximizes strategies for exploring academic content. The literature review explores technological, pedagogical, and content knowledge with instructional practices using Web 2.0 tools. An analysis of the existing literature provides correlations between teacher self-efficacy with STEM area subjects and the online setting.

Technological, Pedagogical, and Content Knowledge

Teaching online has some similarities to a face-to-face setting; however, there were differences in instructional practices. Optimal content integration into the online environment can provide meaningful learning for students (Oster-Levinz & Klieger, 2010). Technological, pedagogical, and content knowledge (TPACK) is the understanding of the intersections between technology, content, and pedagogy (Archambault & Crippen, 2009). A teachers' knowledge of these three components would help provide high-quality instruction. Koehler and Mishra (2009) coined the TPACK framework and stated that teachers in the online environment need technological knowledge and apply this with pedagogy. They also posited that the intersection between all three framework components, the utilization of a technological tool, and pedagogical practices provide an effective lesson design.

Research on pre-service teachers showed a need for more support for incorporating technology with content and pedagogy (Deng et al., 2017; Kiray, 2016; Tømte et al., 2015). A TPACK self-efficacy scale was developed and utilized in 467 senior science education students, with findings showing instrument reliability via a Cronbach's alpha of 0.924 (Kiray, 2016). The TPACK scale can determine pedagogy, content, and technology areas that were the weakest for pre-service science educators (Kiray, 2016). Deng et al. (2017) found evidence for chemistry pre-service teachers' self-reported TPACK scores to be at an upper range of 4.83 out of 7, which showed some proficiency between and across components. The lesson design can improve to include authentic contexts using technology. These authentic opportunities, such as professional development, may offer more preparation in creating lessons and integrating technology effectively into content and pedagogy. Additionally, a case study has shown the importance of preparing teachers for digital competence through TPACK frameworks, designing online courses for the content area, having role models for student teachers, and the opportunity to practice while in the preparation programs (Tømte et al., 2015). The TPACK framework applies to any pre-service or newer teacher who needs professional development in digital competence and lesson design.

Past studies, 1,795 K–12 online teachers in virtual charter schools and 14 high school teachers that provide online tasks, reported the highest knowledge in pedagogy and content and the intersection between both (Archambault & Crippen, 2009; Oster-Levinz & Klieger, 2010). Self-efficacy may be higher in these components because teacher preparation programs and face-to-face classroom teaching may focus on content and pedagogy. However, in this study, virtual teaching had low correlations of self-efficacy in using technology with pedagogy and the intersection of using technology with content (Archambault & Crippen, 2009).

In a further study with high school teachers, Oster-Levinz and Klieger (2010) postulated that teachers' experience levels and guidance positively correlated integrating technological knowledge with pedagogical knowledge. Another recent study finds similar results with high school teachers teaching STEM subjects and integrating technologies that require specific pedagogical and technological practices specific to the subject being taught (Chai et al., 2019). Furthermore, some teachers may be confident in using technology in particular STEM subjects such as science and technology, but minimally in math and engineering. The combined conclusions of Archambault and Crippen (2009), Chai et al. (2019), and Oster-Levinz and Klieger (2010) seem to indicate that integrating technology into teaching predicts teacher self-efficacy. Further research on TPACK proficiency and technology integration into instructional practices may benefit professional development or teacher preparation when specific to a subject.

Web 2.0 Tools to Support STEM Subject Area Online Teaching

A study on teacher self-efficacy and flipped learning showed how delivery changed teachers' attitudes regarding student outcomes (Kelly & Denson, 2017). The delivery method was relevant as teaching programs and professional development will need to bridge any knowledge gaps needed for effective teaching in the online setting. As teachers move from face-to-face instruction to the online format, they need to utilize instructional strategies to teach STEM subjects. Even though the literature was limited to teaching STEM courses in general, collectively positive perceptions can be found. A study on course design for online STEM courses for university students showed student satisfaction in courses which employ active learning, engagement, and assessment strategies (Chen et al., 2018). These strategies in the course design follow the Universal Design for Learning for accessibility and engagement for students. These standards are set by Quality Matters and National Standards for Online Teaching and Courses and provide frameworks for increasing teaching proficiency and best practices in the online environment. In addition, learning and opportunities that provide field experiences may increase teachers' confidence in online courses (Gurley, 2018; Larson & Archambault, 2019).

Research on successful online teaching involves using synchronous and asynchronous settings, which employ online tools, as well as the inclusion of a social modality where students' thoughts can be exchanged with their peers for knowledge construction (Cong, 2020; Oliveira et al., 2019). There was a repertoire of online tools and resources to engage and support students' academic proficiency in STEM subjects when taking courses in the online setting. Oliveira et al. (2019) postulated that emergent technologies could support education through simulation, visualizations, virtual labs, and gaming-type play. Web 2.0 tools allow for interactivity and collaboration and include various modalities from social networks to applications, enabling creating and sharing material. Common Web 2.0 Tools are blogs, podcasts, video and presentation slide production, TED talks, cartoon production, and social networks such as YouTube, Facebook, and Twitter. Research on teacher self-efficacy and integrating Web 2.0 tools in secondary science showed a positive correlation between the two (Alhassan, 2017; Choo, 2020; Wright & Akgunduz, 2018). Teachers with high self-efficacy had higher intentions of using Web 2.0 tools. Online tools such as Powtoon are an option for student learning and assessment to create STEM-type videos about experiments or scientific processes. A study on Web 2.0 tools using Powtoon and a collaborative learning environment for STEM activities were found positive and engaging for students (Bolatli & Korucu, 2018). Such tools may help teachers in the online environment by increasing engagement and allowing additional formative and summative assessment methods.

Several studies found that videoconferencing, usage of at-home laboratory kits and simulations can support the learning process in STEM subjects (DeBoer et al., 2019; Rennar-Potacco & Orellana, 2018; Tibola et al., 2019). Rennar-Potacco and Orellana (2018) posited that video conferencing was an excellent way for teachers to further support students in STEM courses, especially those who need additional aid. Simulations are an option for students attending virtual charter schools. Oliveira et al. (2019) and Tibola et al. (2019) postulated that simulations allow students to manipulate variables and explore phenomena for concepts they were learning. Deng et al. (2017) posited that combining a course, such as chemistry, with teaching approaches and technologies such as Flash or Virtual Chemistry Lab would follow the TPACK lesson design. Brinson (2017) evidenced that virtual labs had a significant positive relationship to student learning outcomes and achievement in the virtual and remote setting. Kefalis and Drigas (2019) confirmed Brinson's (2017) literature review by stating that virtual labs achieve the same results as hands-on labs while saving time and resources. Besides virtual laboratory assignments, STEM interactive simulations from the University of Colorado Boulder, the PhET project, have been a way to increase the understanding of laboratory concepts without using materials. PhET offers lesson plans and 159 free interactive simulations (University of Colorado, 2021). Instructional practices and pedagogy can be active and engaging in the online setting by utilizing technology and web tools.

Ashton (2014) stated that barriers to STEM programs in virtual charter schools include teacher attrition, underprepared educators, and students' diverse population in the United States.

A teacher can minimize these barriers by understanding the needs for course design and the student's instructional needs (Ashton, 2014). As part of the pedagogy, the instructor can determine students' background knowledge to add to the course design for any skills needed. Research continued to share teachers' resistance to implementing STEM activities due to lack of time and resources and inadequate support for implementing technology tools (Ashton, 2014; Harrell & Bynum, 2018). Asynchronous and synchronous settings allow teachers and students to use online tools to support the online learning environment. Teachers can collaborate with their peers, providing verbal persuasion and vicarious experience professional development opportunities to implement Web 2.0 tools into instructional practices. The time taken to discuss the tools may help teachers implement new technology.

Self-efficacy Theory and Professional Development

There was limited research on the statistically significant differences between self-efficacy and professional development for online teaching. However, a study on teacher self-efficacy research suggests that generational and social factors shape self-efficacy, but they can be changed and strengthened through theory and practice (Ofem et al., 2019). More so, teacher self-efficacy can strengthen based on professional development, as evidenced by a study that implemented fifty hours of professional development, which led to significant growth in attitudes about their teaching and student expectancy outcomes (Gardner et al., 2019).

Online Teaching Preparation and Professional Development

Studies of online teachers reveal limited preparation for teaching in the K–12 online setting (Larson & Archambault, 2019). Much of the literature for increasing teacher self-efficacy relates to the undergraduate teacher preparation programs and post-secondary context (Gurley, 2018). The purpose of formal training programs and continued professional learning is to improve pedagogy and instructional practices in the online setting. Research showed that traditional training programs increase educators' confidence levels while teaching online courses (Gurley, 2018; Larson & Archambault, 2019). An effective online teacher can combine technological, pedagogical, and content knowledge (TPACK) while creating an inclusive environment with increased student engagement (Moore-Adams et al., 2016). TPACK can intertwine the understanding of pedagogy, technology, and content knowledge and ensure that instructional practice matches the technology tools and assessment outcomes (Moore-Adams et al., 2016).

Training programs have included virtual field placements for online teachers. In virtual field placement, pre-service teachers observe the K–12 virtual setting while in their college preparation programs (Luo et al., 2017). Luo et al. (2017) asserted that increased online teaching improves positive perceptions after a semester with field experience. Furthermore, Adnan (2018) agrees that individual readiness and online teaching satisfaction have a statistically significant relationship. Even though studies show an increase in confidence, Wynants and Dennis (2018) stated that professional development lacks social interaction, intrinsic motivation, and accountability, which remains a challenge in the online setting. Interviews with faculty who share social presence were valued but felt limited in the online environment, and a Community of Inquiry model may provide the optimum learning experience (Wynants & Dennis, 2018). Providing professional development opportunities for mentorship, peer observation, and professional learning communities may increase teachers' sense of community online.

Rhode et al. (2017) stated that there is limited professional development and a lack of content uniformity and learning experience for teachers in the online setting (Rhode et al., 2017). Ongoing professional development can include strategies such as in-service days where veteran online teachers can share experiences (Luo et al., 2017). In addition, an online community that fosters peer interactions and active learning experiences should complement any professional development program (Lee et al., 2020). The study on statistics online professional development included discussions, analyzing student work, and problem-based collaborations to increase confidence in teaching the subject in this setting (Lee et al., 2020).

Professional development can be based on self-assessments to determine a teacher's online teaching readiness. Each teacher's readiness may suggest areas of need on content, pedagogy, technology integration, online learning management, engagement best practices, or even navigating the learning management system. For example, a quantitative study with 58 post-secondary faculty resulted in an individualized professional development plan, which helped determine professional development needs for each specific educator (Rhode et al., 2017). The self-reported results shared collective and individual results, ranging from beginner to mastery level. In addition, the results included skills about the management of the learning management system through incorporating best practices (Rhode et al., 2017). A survey, such as the T-STEM survey in this study, can determine teachers' confidence level and self-efficacy across STEM subject area teaching, personalized beliefs, and technology usage. This information from the survey may inform a professional development plan to strengthen teacher self-efficacy in the online setting.

Moore-Adams et al. (2016) stated how the research was minimal for experimental studies and information on teachers' essential knowledge and skills in the online setting. Lee et al.’s (2020) asserted the need to identify how to leverage professional development to impact teachers' beliefs about teaching. The need for a robust online teacher preparation program and ongoing professional development has room for growth (Lee et al., 2020; Moore-Adams et al., 2016). In this study, the types of attitudes, skills, and instructional practices were all surveyed. To determine present self-efficacy in elementary, science, technology, engineering, and math, the survey participants were K–12 virtual charter schoolteachers in the United States.

There was growth in teacher proficiencies when personalized learning plans were created and professional development opportunities were offered (Rhode et al., 2017). Rhode et al.'s (2017) quantitative study showed that learning plans were valuable for creating a personalized teacher professional development plan based on self-assessment. The self-assessment helped faculty identify proficiencies in essential skills for their daily tasks related to online teaching. The lack of proficiencies can guide the needed professional development and increase teachers' self-efficacy (Rhode et al., 2017). Yoo (2016) agreed with Rhode et al. (2017) that professional development is an option for increasing teacher self-efficacy. Research evidence showed that 148 online K–12 educators over a five-week online professional development experience effectively increased teacher self-efficacy (Yoo, 2016). Teacher preparation programs may be models for preparing veteran teachers new to the online setting. Cavanaugh and Roe (2019) showed professional development growth over 12 months using the National Standards for Quality Online Teaching. The teacher rating with the most increase was standard A, structures and concepts for effective online instruction, and B, using technology and pedagogy in the online setting. Standard K had significant growth in helping students transfer knowledge online by organizing content. Professional development and learning plans can provide opportunities to learn and practice technology skills, using the TPACK framework for designing lessons, increasing accessibility by the Universal Design for Learning, and using national standards based on online teaching and course setup.

Bandura's Sources to Improve Self-efficacy

The sources to improve self-efficacy, proposed by Bandura (1997), were mastery experiences, vicarious experiences, verbal persuasion, and emotional states. Much of what we know in the education field comes from pre-service teacher preparation and education programs. A study with 783 pre-service teachers showed that each of these four primary self-efficacy sources was a strong predictor of pre-service teacher self-efficacy (Clark & Newberry, 2019). Another study showed that incorporating professional development from mastery experience, vicarious experience, and verbal persuasion could increase teacher self-efficacy (Barton & Dexter, 2020). Experiential and active learning provides access to additional sources of teacher self-efficacy. At the same time, immersive experiences such as vicarious and mastery experiences allow a teacher to learn by directly participating in the learning process.

Vicarious experiences. Vicarious experiences are an opportunity to observe the performance of others. Peer observations are one of the most prominent experiential ways for teachers to gain vicarious experiences**.** Pre-service professional development programs increased pedagogical development in science, technology, engineering, and math (STEM) through vicarious experiences, such as peer observations (Dos Santos, 2020)**.** Peer observations can enhance the observer's confidence and self-efficacy by watching a successful teaching performance (Phuong, 2017). Teachers can observe a colleague during synchronous instructional lessons and even during support sessions for small groups and individual tutoring online. The teacher's ability to record the session to review it or watch later was also possible online.

Mastery experiences. Mastery experiences, which measure the performance's success level, were the most influential for increasing teacher self-efficacy for both beginning and advanced cohort pre-service teachers (Pfitzner-Eden, 2016). Feeling successful in teaching or student achievements can raise the sense of efficacy in future performances (Phuong, 2017). Pre-service and experienced teachers can benefit from additional practice, coaching, and advanced degrees**.** A quasi-experiment on self-efficacy and implementation showed that teachers who participated in professional development had the opportunity to practice and receive coaching, resulting in the most substantial effect on self-efficacy beliefs (Tschannen-Moran & McMaster, 2009). The act of practicing and gaining accomplishments further increases teacher self-efficacy. In addition, mastery and coaching experience can lead to higher student achievement, further affecting teacher self-efficacy. Professional development and learning series can be modeled after teacher preparation programs to provide a supportive program for teachers newer to teaching in the online setting.

Verbal persuasion. Formal professional development frequently comes in verbal persuasion, which is the opportunity for teachers to converse with colleagues about successful teaching performance (Phuong, 2017). Verbal persuasion can occur during in-service training, mentorship program, professional learning community, and even a conference or workshop attendance. A popular verbal persuasion can come from peers, sometimes called social persuasion. A professional learning community (PLC) allows colleagues to take individual self-efficacy and make it collective. This collaborative opportunity allows colleagues to share best teaching practices while reflecting on instructional practices (Zheng et al., 2019). Wright et al. (2019) recommended that experienced STEM teachers serve as mentors to guide newer teachers. Verbal persuasion in the online setting can be possible through videoconferencing tools, asynchronous discussion boards, and collaboration using Web 2.0 Tools, such as the Google Suite of tools.

Emotional states. Emotional states have an impact on teacher self-efficacy. Fear may result in lower self-efficacy, while a positive experience can increase the sense of self-efficacy in teaching (Phuong, 2017). Buonomo et al.'s (2019) study on 272 Italian school teachers' positive emotions may help teachers be more resilient after a challenge or negative experience. The higher teacher’s perceived self-efficacy, the higher the positive emotions were found. Leadership includes a positive school climate with a goal of increased teacher self-efficacy, which may lead to a myriad of positive benefits, such as job satisfaction, commitment to the profession, and higher student performance (Chesnut & Burley, 2015; Demir, 2020; Larkin et al., 2018; Shahzad & Naureen, 2017). Professional development and learning are possible to create more confidence and mastery experiences. A servant leader can provide ample professional development opportunities, which create a supportive school environment. The school environment provides its teachers with vicarious experiences, mastery experiences, and verbal persuasion; it sets the basis of a community of learners who grow alongside and with each other.

Contrary Literature

Borup and Stevens (2017) stated that online teachers correlated job satisfaction to "flexibility, communication and community, and success and support" (p. 5). Higher self-efficacy links to higher job satisfaction, retention, and student achievement (Chesnut & Burley, 2015; Demir, 2020; Larkin et al., 2018; Shahzad & Naureen, 2017). Studies have found that online teachers perceived online teaching as more managerial and social rather than dependent on content-related strategies (Corry & Stella, 2018). This perception coincided with another study which showed that online virtual teachers desired more professional development in other areas such as subject-based integration of content with technology (Lin & Zheng, 2015). Any area in which a teacher is ineffective may lead to a disconnect in job satisfaction if there has been limited preparation and professional development for newer online teachers. Corry and Stella (2018) showed that online teachers with more web experience had higher self-efficacy strategies. The years of virtual teaching experience may be a more critical factor in self-efficacy in the online setting.

Despite several studies which depicted student performance and teacher self-efficacy's positive outcomes, current research showed that the correlation was negligible (Martin & Mulvihill, 2019). Correlation does not mean causation, and a teacher with low self-efficacy does not correlate with them being ineffective. Siwatu et al. (2016) postulated that newer teachers and lower self-efficacy might motivate teachers to develop more skills and help prevent teacher burnout.

Preparation and professional development may increase teacher self-efficacy, which leads to job satisfaction, retention, and student achievement. Clark and Newberry's (2019) study asserted a different perspective, showing that teacher education programs increase pre-service teachers' self-efficacy. However, the data indicate additional sources contributed to teacher self-efficacy. This research was limited to pre-service teachers' educational experiences, but those experiences upon conferral of the degree positively correlated with improved teacher self-efficacy. Mastery experiences, vicarious experiences, and verbal persuasion predict whether a pre-service teacher has self-efficacy (Clark & Newberry, 2019). Leadership plays an integral part in teachers' self-efficacy development but finding the time for these opportunities even if limited. A study of 249 principals from 112 school districts revealed that while professional development was essential, time constraints posed a challenge (Koonce et al., 2019). Both in the school context and the time needed to be made available for online course preparation, faculty may, as studies show, have limited access to professional resources (Espinoza & Neal, 2018). This research shared the various types of professional development opportunities available that may be utilized when faced with time constraints. This study's survey compared teachers' teaching self-efficacy and attitudes towards STEM, the dependent variable, with the STEM subject area and virtual teaching experience level being the independent variables.

Gap in the Literature Review

The shortage of K–12 STEM teachers and a growing need for more virtual charter schoolteachers require more professional development support (Molnar et al., 2019; Moore-Adams et al., 2016; Wright et al., 2019). Research on self-efficacy was predominantly in pre-service teachers' context, and preparation for teaching in the online setting was minimal (Moore-Adams et al., 2016). Much of the research has focused on the traditional face to face setting, pre-service teachers, and faculty in post-secondary programs (Clark & Newberry, 2019; Deng et al., 2017; Dos Santos, 2020; Luo et al., 2017; Pfitzner-Eden, 2016; Tømte et al., 2015; Wright & Akgunduz, 2018). This research filled a gap in the awareness of the teaching self-efficacy in the science, technology, engineering, and math (STEM) subject areas in the online setting of virtual charter schools. The research informed mean statistical differences in teaching self-efficacy levels and attitudes towards STEM with teachers working in the K—12 online setting compared to STEM subject areas and years of virtual experience. Teachers with higher self-efficacy remain more committed to teaching (Chesnut & Burley, 2015). This research's outcomes informed instructional leaders of professional development opportunities to increase teacher self-efficacy and support secondary science, technology, and engineering teachers.

Chapter Summary

The current literature review provided insight into teacher self-efficacy and online teaching in STEM subjects and teacher self-efficacy and professional development. The theoretical framework for the research study was the Self--efficacy theory and Servant leadership theory. The literature review concluded with a review of the contrary literature and a summary. There remained a gap in the literature for self-efficacy in the science, technology, engineering, and math subject areas in online virtual charter schools. The study filled this gap by determining whether a significant difference exists between teacher efficacy and experience and STEM subjects in virtual charter schools located in the United States. The research results elaborated and added to the existing literature to determine the mean composite scores for teacher self-efficacy in the STEM subjects and with varying years of virtual teaching experience. The research design, methodology, data collection, and analysis used in this study follow in Chapter Three.

Chapter 3: Methodology

The purpose of this quantitative causal-comparative study was to determine if a statistically significant difference exists between science, technology, engineering, and math (STEM) subjects and virtual teaching experience (0–2 years, 2–5 years, and more than five years) on teacher efficacy and attitudes towards STEM. The problem is little literature on how teacher efficacy impacts subject matter teaching beliefs, perceived student teaching outcome expectancy, and subject matter instruction in the online setting. In addition, school districts across the United States have reported acute shortages of teachers, especially in mathematics and science, with teacher turnover rates being higher for the same (Darling-Hammond et al., 2018). The research was a non-experimental, causal-comparative research design that tested if there is a statistically significant difference between years of virtual teaching experience, STEM subject areas, and composite scores on the Teacher Efficacy and Attitudes Toward STEM (T-STEM) Survey. The research questions, including the null and alternative hypothesis guiding the research, were as follows:

Research Question One: Does a statistically significant difference exist between the independent variable of the subject matter of science, technology, engineering, and math (STEM) and the dependent variable of teacher self-efficacy and attitudes towards STEM, as measured by the T-STEM survey from teachers in virtual charter schools in the United States?

$H1_o$: There is no statistically significant difference in mean teacher self-efficacy and attitudes toward STEM scores, as measured by the T-STEM survey, between teachers who teach STEM subjects (science, technology, engineering, and math) in a virtual charter school in the United States.

$H1_a$: There is a statistically significant difference in mean teacher self-efficacy and attitudes toward STEM scores, as measured by the T-STEM survey, between teachers who teach STEM subjects (science, technology, engineering, and math) in a virtual charter school in the United States.

Research Question Two: Does a statistically significant difference exist between the independent variable of virtual teaching experience, with categories (0–2 years, 2–5 years, and more than five years) and the dependent variable of teacher self-efficacy and attitudes towards STEM, as measured by the T-STEM survey in virtual charter schools in the United States?

$H2_o$: There is no statistically significant difference in mean teacher self-efficacy and attitudes toward STEM scores, as measured by the T-STEM survey, between teachers' virtual teaching experience (categories 0–2 years, 2–5 years, and more than five years) in a virtual charter school in the United States.

$H2_a$: There is a statistically significant difference in mean teacher self-efficacy and attitudes toward STEM scores, as measured by the T-STEM survey, between teachers' virtual teaching experience (categories 0–2 years, 2–5 years, and more than five years) in a virtual charter school in the United States.

Research Question Three. Does a statistically significant interaction exist between the independent variables of STEM subject matter and virtual teaching experience, with categories 0–2 years, 2–5 years, and more than five years, exist in the dependent variable of teacher self-efficacy and attitudes, as measured by T-STEM in virtual charter schools in the United States?

$H3_o$: There is no statistically significant interaction effect between teachers who teach STEM subjects (science, technology, engineering, and math) and virtual teaching experience (categories 0–2 years, 2–5 years, and more than five years) in a virtual school in the United

States in terms of teacher self-efficacy and attitudes toward STEM scores, as measured by the T-STEM survey.

$H3_a$: There is a statistically significant interaction effect between teachers who teach STEM subjects (science, technology, engineering, and math) and virtual teaching experience (categories 0–2 years, 2–5 years, and more than five years) in a virtual school in the United States in terms of teacher self-efficacy and attitudes toward STEM scores, as measured by the T-STEM survey.

The methodology restated the study's purpose and design to answer the research questions. The research design included the researcher's role, procedures, instrumentation, data collection methods, and data analysis. The conclusion of the methodology focused on reliability, validity, and ethical considerations throughout the research.

Research Methodology, Design, and Rationale

This study used a quantitative methodology to determine if a statistically significant difference exists between science, technology, engineering, math (STEM), and teaching experience on teacher efficacy and STEM attitudes from teachers from virtual charter schools in the United States. The context for this study was 92 teachers from K–12 virtual charter schools in the United States. A causal-comparative design was used to find statistically significant differences among the dependent and independent variables.

Methodology

The quantitative method received objective, numerical data explaining phenomena through statistical analysis (Muijs, 2011). Qualitative and mixed methods were not appropriate for this study since the research was more exploratory and aimed to determine significant differences between the dependent and independent variables. It might be costly to do experimental research if exploratory research on the significant difference was null. Qualitative and mixed methods might be appropriate if self-efficacy was lower in the K–12 virtual charter school environment. Salkind (2012) stated that the techniques used for qualitative studies were more personal, such as case studies, interviews, or mixed response surveys. Quantitative studies are suited for testing hypotheses (Muijs, 2011). This study's research questions and hypotheses determine a significant difference between STEM subject areas, years of virtual teaching experience, and self-efficacy and attitudes towards STEM.

Design

The methodology was quantitative and aimed to explain the phenomena of teacher self-efficacy in the online setting. A quantitative methodology was appropriate because it identified a research problem, explained why something may occur, and then informed the findings for the context (Creswell & Guetterman, 2019). The results informed current virtual charter school leaders of the current levels of self-efficacy in STEM subject areas and a statistically significant difference between STEM subject areas and years of virtual teaching experience.

A causal-comparative research design is a possible method when variables may not be manipulated but comparing statistically significant differences between variables is valuable (Salkind, 2010). This research allowed for finding differences in variables between groups. The research design was suitable for testing the hypotheses because it determined if there was a statistically significant difference between the independent variables, STEM subject areas, and virtual teaching experience, and the dependent variable of the mean total composite score on the T-STEM survey (Creswell & Creswell, 2018, p. 147). The alternative experimental methods were not possible since the research analysis was ex post facto, determining current self-efficacy levels and attitudes towards STEM. Quantitative causal-comparative research was exploratory and can limit the time–consuming and costly experimental research process (Salkind, 2010). The anticipated benefit to the causal-comparative design was discovering concerns about teachers' self-efficacy in virtual charter schools, which may become apparent. Experimental research may be warranted if the results show a cause-and-effect-significant difference of self-efficacy with the independent variables of STEM subject area and virtual teaching experience.

The independent variables were the teachers' STEM subjects and virtual teaching experience. The experience levels were categorical with three groups (0–2 years, 2–5 years, and more than five years). The dependent variable was the total composite score on the Teacher Efficacy and Attitudes Toward STEM (T-STEM) survey. The demographics of the participant was completed at the start of the survey. The demographics included years of virtual teaching experience and whether the teacher was elementary or secondary in science, technology, engineering, and math. The survey results gave a composite self-efficacy score and compared the independent variables for significant differences.

The statistical test was a two-way analysis of variance (ANOVA), which compared groups and tested for significant differences between dependent and independent variables. A two-way ANOVA compared the means of grouping the variables and a difference among group means in a sample (Keselman et al., 1998). The statistical test helped to determine if there were any significant group differences between the independent variables: STEM subjects of science, math, technology, engineering, and math, and virtual teaching experience (0–2 years, 2–5 years & 5+ years) with the dependent variable, which was the mean composite scores of teacher efficacy and attitudes towards STEM.

Causal-comparative Research Design

The causal-comparative design aimed to determine significant differences-among the independent and dependent variables in the online survey, which was appropriate because there was no random assignment or manipulation of the independent variables, and the central goal was determining significant differences between variables (Johnson & Christensen, 2019, pp. 42–45). Causal-comparative research designs are conventional in social sciences, such as education, where variables cannot be or should not be manipulated and have already occurred in a circumstance or setting (Salkind, 2010, p. 198). Experimental research studies provide results which may be more generalized, and causal-comparative studies are less time-intensive and require fewer resources. When school districts want to determine if significant differences exist, causal-comparative research may be necessary. The results may be reviewed to determine if further experimental studies are warranted (Fraenkel et al., 2018).

Role of the Researcher

The quantitative researcher's role was to add to the literature's knowledge base, provide new ideas, and improve the practice through an unbiased methodology (Creswell & Creswell, 2018). The instrument, an online survey, was posted on social media groups related to teaching. The purposive sampling included a Facebook advertisement. The advertisement was posted automatically by Facebook to recruit the targeted audience of K–12 certified teachers with virtual education interests. The survey culminated with the link to the SurveyMonkey survey and a request for snowball sampling, where participants recruit other STEM subject area teachers in the K–12 virtual charter school setting. There were no personal and professional relationships the researcher had with participants. While the researcher works for an educational technology curriculum provider, and some virtual charter schools use a digital curriculum, it was ensured that the participants had no contact with the researcher. The participants had directions and informed consent as part of the survey (see Appendix A).

Potential participants knew about the research by recruitment, advertisements, and by participants recruiting other participants. This anonymity limited any conflict of interest. The research process included the directions and informed consent in the digital survey, ensuring the participants knew the research objectives, risks, and benefits of participation and consented to participate (Creswell & Creswell, 2018). The study included the demographics questions but was anonymous to protect the privacy and keep the results confidential. The exclusion criteria included in the survey determined if the teacher meets the study's participation requirement.

Research Procedures

The research procedures described the population and the sample selection participating in this quantitative study. A purposive sampling and targeted snowball sampling obtained survey results from K–12 virtual teachers in the United States. Educators had access to the survey link to share with colleagues in the sample population at completion. Data collection was via an anonymous online survey-The Teachers Attitudes Toward STEM Survey (T-STEM), developed by Friday Institute (Friday Institute for Educational Innovation, 2012a, 2012b, 2012c, 2012d, 2012e). A two-way ANOVA test was conducted and statistically analyzed with the most current SPSS software version. The research procedures outlined the population, sample selection, instrumentation, and data collection methods.

Population and Sample Selection

The sample population was 92 virtual charter schoolteachers in grades K–12 in science, technology, engineering, and math (STEM) in the United States. According to Salkind (2010), convenience sampling is an inexpensive and convenient method that allows selecting participants that are easily accessible (Salkind, 2010). The purposive sampling methods recruited participants from social media networking sites Facebook and LinkedIn.

Recruitment of participants from social media groups was after approval from the administrator of the Facebook groups. This study's social media recruitment sites were from Facebook groups (see Appendix B). The outreach template was sent to group site administrators to gain approval for posting to their groups (see Appendix C). The approval from site administrators to post within the Facebook group was received before recruiting (see Appendix D). The recruitment of participants on the Facebook groups involved posting on the Facebook Wall of each group's homepage (see Appendix E). A Facebook and LinkedIn advertisement was used to recruit from an audience of certified teachers with interests in K–12 education, virtual learning, and charter schools in the United States (see Appendices F and G). The sampling method included a snowball sampling from participants in the study who may know colleagues who meet the survey's inclusion criteria (see Appendix H). The survey completion depended on the participant's willingness to participate in the study. While convenience sampling methods may not be generalizable to the general population, the data may provide information that helps compare means between different variables (Creswell & Guetterman, 2019).

The sample size determined the level of precision and confidence, as well as variability in the groups (Cochran, 1977; Israel, 1992). The sample size formula determined the number of participants needed to ensure the appropriate number. The tool G*Power (version 3.1.2) with statistical power and effect size determined the sample size needed (Faul et al., 2009). A sample size of at least 92 completed surveys from teachers in science, technology, engineering, and math was needed to have a statistical power of 80%, an effect size of 0.4., and an alpha level of error of 5% (see Appendix H). The study's effect size (d) was 0.4, i.e., a medium effect (Cohen, 2013).

The larger the effect size, the stronger the relationship is between variables. Cohen (2013) posited that social science power is set conventionally at 0.80. Collecting demographics and virtual teaching experience information were the first questions in the online survey to allow for inclusion and exclusion criteria. The survey included the background of the research and agreeance to informed consent before participating. Inclusion criteria included participants who teach elementary or secondary subject areas of science, technology, engineering, or math in a virtual charter school in the United States. Exclusion criteria were teachers in subjects areas that are not elementary, science, technology, engineering, and math. Exclusion criteria were those not working in a virtual charter school in the United States in grades K–12.

Instrumentation

The data was collected using the Teacher Efficacy and Attitudes Toward STEM Survey (T-STEM) survey (see Appendix K). The instrument was developed in 2012 and was permitted to use by Friday Institute (see Appendix L). The survey was related to the research questions because the results help determine a significant difference among the dependent variable, teacher self-efficacy levels, independent variables, STEM subject area, and years of teaching experience. The research question also determined if there was a statistically significant interaction across the independent variables. At the beginning of the survey, demographics were required to determine significant differences in grade level, subject area, and years of virtual teaching experience. Then, the independent variables were tested to see a significant difference between each group.

T-STEM Survey

The T-STEM survey gave information on teacher self-efficacy and attitudes towards STEM regarding teaching and how teachers affect student learning. In addition, the survey provided information on the frequency at which students use technology and use certain STEM instructional practices, the teachers' attitudes towards 21st-century learning and leadership, and their awareness of STEM careers (Friday Institute for Educational Innovation, 2012f). There were five versions of the survey, one for each STEM area (Science, Technology, Engineering, and Math) and one for elementary.

The five-point Likert scale questionnaire was converted to a web-based Likert survey and was posted on the Internet on social media sites such as LinkedIn and Facebook. The digital survey, SurveyMonkey, allowed customizing survey questions and added data security features that encrypted results (LaFollette, 2018). This individual teacher data, the dependent variable, was compiled and analyzed with the independent variables, STEM subject matter teaching, and virtual teaching experience. The data was exported from the web-based survey program, number-coded, and locked in a file cabinet. The two-way ANOVA statistical analysis helped answer the research questions and determine a significant difference between the dependent and independent variables.

Instrument Validation

The T-STEM survey was constructed using existing surveys to develop comprehensive information concerning many aspects of STEM education. There were seven constructs to the survey, with 63 questions. The Development and Psychometric Properties guide provided access to the survey and pilot study's foundational background (Friday Institute for Educational Innovation, 2012f). The pilot study consisted of 257 science teachers, 72 technology teachers, 17 engineering teachers, and 12 math teachers. The Cronbach's Alpha, i.e., the construct reliability levels, was calculated for each subject area and construct, ranging from 0.870 to 0.948. Cronbach's Alpha is a reliability measure that showed the instrument's internal consistency on a population with numbers of 0.70 or higher as an acceptable value (Taber, 2018). The final surveys were analyzed using exploratory factor analysis, and each factor showed that no changes were necessary to the survey (Friday Institute for Educational Innovation, 2012f).

Data Collection and Preparation

American College of Education International Review Board approved to recruit participants (see Appendix M). The sampling methods were purposive sampling by recruiting social media groups related to teaching and virtual charter schools. Additionally, a targeted Facebook advertisement focuses on an audience of certified teachers with interests in K–12 education in virtual and charter schools in the United States. Finally, a targeted snowball sampling concluded the survey where educators had access to the link to share with colleagues who meet the research study's inclusion criteria. Surveys provided a numerical account of a sample population's attitudes and opinions, drawing generalizations about a particular group (Creswell & Creswell, 2018).

Friday Institute granted permission to use the T-STEM surveys for subject areas of science, technology, engineering, and math (see Appendix L). The surveys were turned into digital versions using SurveyMonkey, a web-based service which allows users to develop customizable surveys. The anonymous survey had background information of the study and the agreeance to informed consent before participation. The informed consent allowed the participants to make an informed decision based on research details, the contact information of the researcher, the utilization of the data, the length of time to complete the survey, and any risks involved by participating (Sue & Ritter, 2012). Once participants check a box in agreement, they can participate in the survey. The survey included initial questions about the independent variables, i.e., STEM subjects they teach and years of virtual teaching experience.

As teachers completed the survey, the SurveyMonkey application compiled the data into a spreadsheet. The results were password protected and downloaded when the data was processed. The data and storage media were stored in a locked file for three years. According to the authors of the article, “Data Management Practices in Educational Research,” Owan and Bessey (2019) posited that any papers must be cross-cut shredded, and thumb drives may be physically destroyed. The SurveyMonkey account was permanently deleted along with associated data.

Data were reviewed, cleaned, and coded to prepare for analysis (Jones & Hidiroglou, 2013) on an Excel spreadsheet which contained four columns: participant number, STEM subject area, virtual teaching experience, and T-STEM total composite score. First, the data was downloaded from Survey Monkey and then reviewed for formatting errors in Microsoft Excel. Next, the data was cleaned of empty rows of columns where participation was declined, or the survey was not complete. Finally, the data was coded, with numeric values representing variables and codes for questions and answers. The data codebook was a .xlsx saved format, readily usable for importing data into the SPSS statistical software.

Data Analysis

The utilization of SPSS statistical software provided a comparison of means in the data analysis. Researcher Muijs (2011) stated that ANOVA was used in educational research to compare the group's variance with the groups' variance (p. 186). This research focused on the mean scores of the teacher efficacy and attitudes towards STEM, the dependent variables, and the difference between STEM teachers and virtual teaching experience, the independent variables.

The data cleaning included reviewing participants' responses, including incomplete or inconsistent answers, or choosing the same answer for each question. Participants who chose the same answer may be speeding and not thinking about the answer. The screening procedure included reviewing the raw data for errors and testing the two-way ANOVA's assumptions. The six assumptions for a two-way ANOVA need to be tested and met to use this test. Laerd Statistics (year) stated that the six assumptions were (a) independent variables measured at the continuous level; (b) the two independent variables should consist of two or more categorical, independent groups; (c) there should be independence of observations; (d) no significant outliers; (e) dependent variable should be approximately normally distributed for each combination of the groups of the two independent variables; and (f) homogeneity of variances (HOV) for each combination of the groups of the two independent variables (Laerd Statistics, 2018).

The total composite scores from the Likert survey, the dependent variable, were treated as a continuous variable. ANOVA testing was used because it is robust and tolerant to skewed data (De Winter & Dodou, 2010; Norman, 2010). The first three assumptions were controlled before testing. In contrast, normality assumptions between groups of independent variables, no significant outliers, and homogeneity of variance were reviewed before running the two-way ANOVA. Normality testing was visually assessed by viewing the normal probability plot of the Shapiro-Wilk test in SPSS, with the one standard deviation of the mean being approximately 68.26% of responses, two standard deviations of the mean being 95.44% of the responses, and three deviations from the mean having 99.14% responses (Garson, 2012). Testing for significant outliers was checked in an SPSS boxplot output, with values beyond the whiskers being an abnormal distance from other values (Garson, 2012). Lastly, Levene's homogeneity of variances was tested within SPSS as a one–way t-test. The test rejected the null hypothesis of equal populations if the significance was more than 0.05 (Garson, 2012).

The data analysis plan aligned the research questions, study design, and measurements to ensure alignment. Researcher Simpson (2015) identified the need to identify relevant inferential statistics by the type of research question asked (Simpson, 2015). A causal-comparative study determined if the dependent variable—the average mean score on the teacher efficacy and attitudes towards STEM and the independent variable—STEM subjects teachers' years of teaching experience—were significant. The two-way ANOVA tested if the null hypotheses were rejected if a significant difference was identified in the dependent variable categories when tested for the T-STEM survey's average mean scores. When the results show a significance in interaction, the simple main effects were reported. A Games-Howell post hoc analysis was utilized since a significant difference was found to determine which groups differ. Post hoc testing was utilized when the homogeneity of variance was met to determine differences between group means (Allen, 2017).

For research questions one and two, the *F*-Test results determined if significant differences between STEM subjects and years of virtual teaching had statistically significant differences in each hypothesis. According to Laerd Statistics (2018), the *F* value determines whether the data is statistically significant. Additionally, results did not occur by chance, meaning the null hypothesis cannot be rejected (Laerd Statistics, 2018). The null hypothesis can be rejected if the F value is larger than the F critical value. The statistical significance of the effect depends on the *p*-value of the *F*-test. If the *p*-value is less than or equal to the significance level set at 0.05, there is a significant statistical difference, and the null hypothesis is rejected (Seltman, 2018). For Research Question Three, the results aimed to determine whether a significant interaction exists between subject matter in STEM and virtual teaching experience in terms of teacher self-efficacy and attitudes towards STEM scores, as measured by the T-STEM survey. The interaction was interpreted by the simple main effect: the differences of one dependent variable at each level of the dependent variable. The study has five independent groups for subjects (science, technology, engineering, math, elementary) and three groups of the second independent variable of years of virtual teaching experience (0–2 years, 2–5 years, five or more), resulting in 5 x 3 factorial or 5 x 3 ANOVA.

External validity was the research's validity being generalizable and repeatable in other populations, settings, and measures (Creswell & Creswell, 2018). The three threats to external validity were the limitation of generalizability beyond the groups tested, the school setting, and the time of completion of the survey. The groups tested were STEM subject areas and virtual teaching experience. The online survey delivery had a standardized process to ensure equal participation and fairness to all populations. Another two threats to external validity were the ability to generalize beyond virtual charter school settings in the United States and generalizing the findings according to the past and future. The settings may produce different data results, depending on the school's type, location, and teacher preparation in another state. Repeating this research in various settings and alternate contexts may increase generalizability. For example, the survey may be given at the end of the year, and results may differ if given at different times. The results may be more generalizable if taken at the same period as this research.

There were potential threats in this causal-comparative research design, such as non-random assignment, selection, maturation, and mortality (Creswell & Creswell, 2018). The threat of selection bias and outliers is higher in non-probability, convenience samplings methods such as purposive sampling (Etikan et al., 2016). The inclusion and exclusion criteria helped determine the population needed was in the data analysis. The inclusion data included participants who teach secondary science, technology, engineering, or math in virtual charter schools located in the United States. A sampling selection technique compared homogeneous subgroups clustered by a variable that controlled the sample and reduced counter threats to internal validity (Salkind, 2010). In this research, the independent variables of STEM subject area and virtual teaching experience compared subgroups to control each variable. Mortality and maturation were a negligible threat as the survey was only available once.

Reliability measures consistency and reproducibility of outcomes when a test measures the same thing (Salkind, 2010). Errors such as method and trait error reduce the reliability and consist of individual characteristics, individual factors, and test administration factors (Salkind, 2010). The instructions and informed consent were standardized, clear, and concise to limit participant response confusion or variance. The instrumentation selected has already been tested for reliability with a Cronbach's Alpha of 0.870 to 0.948. Internal consistency was met when Cronbach Alpha was more significant than 0.70 (Taber, 2018). Quantitative research aims to have objectivity throughout the research process. Mertler (2021) postulated data collection through questionnaires and data analysis through statistical methods and reported the results in tables and charts to reduce subjectivity and bias. The survey was anonymous to increase objectivity and reduce any bias in this research. The T-STEM survey had postings in social media groups and a request to share with colleagues and peers to distance the researcher and participant.

Ethical Procedures

The Belmont Report, from the Department of Health, Education, and Welfare, sets guidelines to maintain respect for persons, beneficence, and justice throughout research

(Creswell & Creswell, 2018). Before, during, and after research, considerations were taken to protect participants from harm and maintain privacy. Participants were able to withdraw from the research at any time. The posting and recruitment of participants provided all necessary information and the links to the surveys for any elementary and secondary science, technology, engineering, and math teachers. The anonymous online survey had the background to the research, instructions, and informed consent on the first page. The background shared the purpose of the research, potential benefits or risks to the participant, an offer to withdraw at any time, and assurance of privacy and confidence throughout the research (Salkind, 2010). Informed consent requires an agreement before a participant may proceed with any questions.

Data was kept confidential and saved in an external storage drive stored in a locked filing cabinet for three years and then destroyed. According to the authors of the article, “Data Management Practices in Educational Research,” Owan and Bassey (year) posited that any papers should be cross-cut shredded, and external storage drives may be physically destroyed (Owan & Bassey, 2019). The SurveyMonkey account was deleted after the data analysis was complete. There were no conflicts of interest, and the researcher did not contact any of the participants directly. While the researcher works for an educational technology curriculum provider and some virtual charter schools use a digital curriculum, the research process did not directly involve the researcher.

Chapter Summary

The methodology included the purpose of the study, research questions, and hypotheses, which drove the research to determine if subject area and virtual teaching experience have a statistically significant difference in Teacher Efficacy and Attitudes Toward STEM (T-STEM) survey. The participants came from purposive sampling from social media sites online and targeted snowball sampling. Targeted snowball sampling offered recruitment from participants. The data of the T-STEM was run within the SPSS statistical software package. In this causal-comparative research, generalizations were limited to this study, with participants from subject areas of science, technology, engineering, and math in virtual charter schools in the United States (Creswell & Creswell, 2018). The research questions were constructed to determine if there was a statistical significance between independent variables of science, technology, engineering, and technology subjects, virtual teacher experience, and the dependent variable of teacher self-efficacy and attitudes towards STEM, as measured by T-STEM scores. The research findings and statistical analysis follows.

Chapter 4: Research Findings and Data Analysis Results

Teaching self-efficacy research is minimal in the K–12 online setting, particularly science, technology, engineering, and math. The problem is that there is little availability of information in the literature on how teacher self-efficacy impacts STEM subject matter teaching beliefs in the online setting in virtual charter schools in the United States. In addition, research is limited to teacher preparation programs and with faculty in higher education. The purpose of this quantitative causal-comparative study was to test for statistically significant differences between STEM subject area teachers (science, technology, engineering, and math) and experience (0–2 years, 2–5 years, and more than five years) in teacher self-efficacy in the K–12 virtual learning environment. The research findings and data analysis results shared data collection methods, analyzed results using two-way ANOVA, and provided reliability and validity of the study.

Data Collection

Data were collected from participants on Facebook and LinkedIn, among other social media platforms, through purposive and snowball sampling methods. A targeted snowball sampling concludes the survey where educators had access to the link and could share it with colleagues (see Appendix K). The anonymous survey had background information of the study and agreeance to informed consent before participation. The data used were from teachers who meet all three inclusion requirements of working full-time for a virtual charter school in grades K–12 and with elementary grades or subject areas of science, technology, engineering, and math. After the informed consent statement, the qualification page advanced participants if they met these three conditions (see Appendix I).

The time frame for data collection was 51 days from June 23, 2021, through August 12, 2021, through SurveyMonkey. There were no deviations from the data collection methods. The participants were full-time virtual charter school teachers in elementary grades or subject areas of science, technology, engineering, and math (*n* = 104). The response rate from Facebook advertisements and Facebook groups was 24%. In addition, a 3% response rate was achieved from LinkedIn advertisements.

Demographic Profile

After the inclusion criteria were met in the survey, the demographics of both subject matter and years of virtual teaching experience were analyzed. Of the 104 completed surveys, 39 (37.5%) came from elementary teachers that teach math and science. For secondary teacher respondents, 24 (23.1%) taught science, 12 (11.5%) technology, 9 (8.7%) engineering, and 20 (19.2%) were math teachers. Table 1 provides an overview of the frequency and percentage of respondents in each subject matter category.

Table 1

Subject Matter of Participants

Subject Matter	Frequency	Percent
Elementary (Math and Science)	39	37.5
Science	24	23.1
Technology	12	11.5
Engineering	9	8.7
Math	20	19.2

Note. Frequency and percentages by subject matter.

Table 2 provides an overview of the demographic profile of the respondents based on years of virtual teaching experience. The categorical data for years of virtual experience were coded from the survey responses (1 = 0–2 years, 2 = 2–5 years, 3 = 5 or more years). Elementary teachers had the highest representation in the survey responses, with 22 respondents with 0–2 years of virtual teaching experience. Science teachers had the most representation in the five or more years of experience, 2–5 years for technology, 0–2 and 2–5 years for engineering, and five or more years for math.

Table 2

Years of Virtual Teaching Experience of Participants

Years	Frequency	Percent
0–2	43	41.4
2–5	33	31.7
5+	28	26.9

Note. Frequency and percentages by years of virtual teaching experience.

Table 3 shows the frequency of virtual teaching experience across subject matter for comparison across groups. The highest representation of completed surveys was from elementary teachers with 0–2 years of virtual teaching experience. The lowest representation was from engineering teachers with five or more years of experience.

Table 3

Virtual Teaching Experience Frequency by Subject Matter Categories

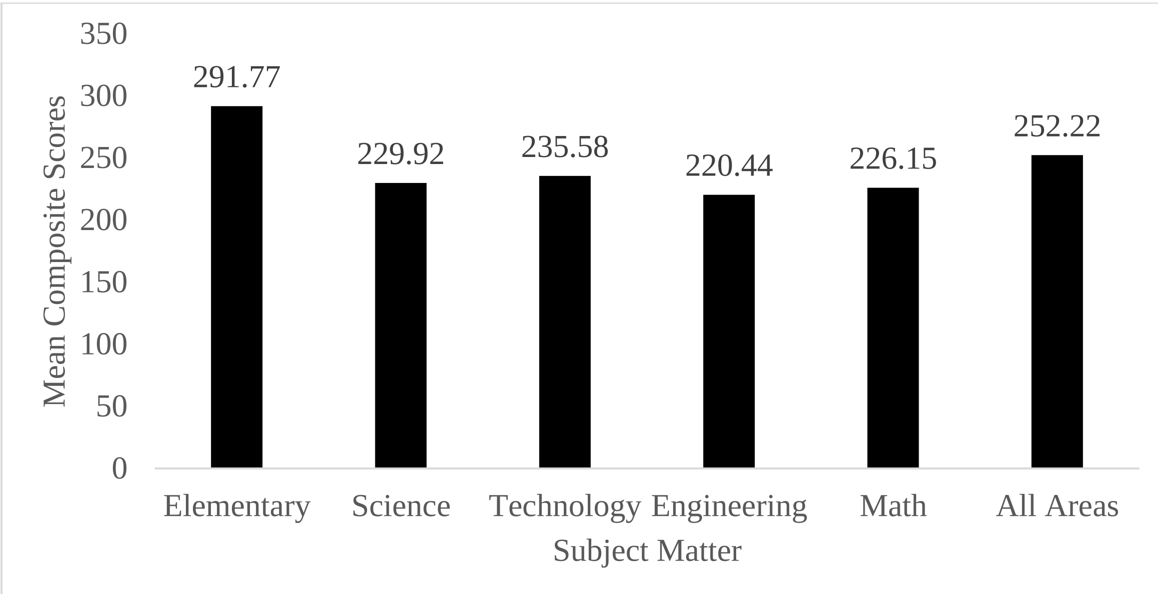
	Frequency		
Subject Matter	0–2 years	2–5 years	5+ years
Elementary (Math and Science)	22	10	7
Science	7	8	9
Technology	4	5	3
Engineering	4	4	1
Math	6	6	8

Note. Independent variable of years of virtual teaching experience for completed surveys.

As shown in Figure 3, the mean composite self-efficacy and attitudes toward STEM scores (CSE) show the highest values for elementary teachers, with 291.77. Secondary STEM teachers were similar and within one standard deviation (SD = 44.62). The mean composite scores for all subject matter areas had a CSE of 252.22.

Figure 3

Mean Composite Self-efficacy Scores

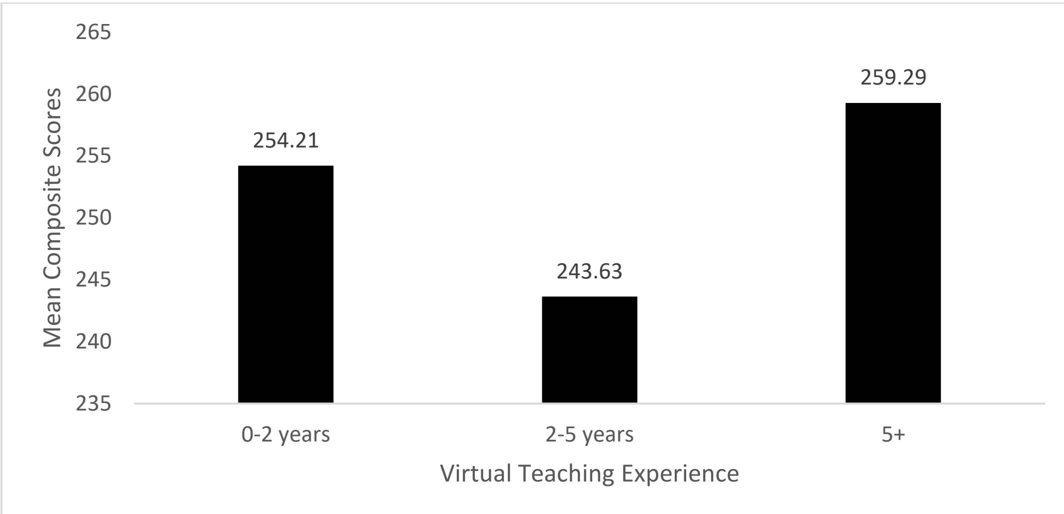


Note. Mean composite scores of self-efficacy and attitudes towards STEM by subject matter among respondents.

The survey data was compiled by years of virtual teaching experience. As shown in Figure 4, the mean composite self-efficacy and attitudes toward STEM scores (CSE) showed the highest values for teachers with five or more years of virtual teaching experience. The mean composite scores were lowest for the group of teachers that taught between two through five years.

Figure 4

Mean Composite Self-efficacy Scores



Note. Mean composite scores of self-efficacy and attitudes towards STEM by virtual teaching experience among respondents.

Data Preparation

Data was reviewed, cleaned, and coded to prepare data analysis (Jones & Hidiroglou, 2013). The 104 completed surveys obtained from SurveyMonkey were downloaded in an Excel spreadsheet. The Excel spreadsheet contained four columns: participant number, subject area, virtual teaching experience, and the T-STEM total composite score. Participants who did not qualify based on the inclusion criteria, agree to informed consent, or complete the survey were removed from the spreadsheet. The collection was from 162 participants, and once the data was cleaned, 104 qualified responses were found. The 58 exclusions were from teachers who taught in a subject outside of the inclusion criteria (elementary, science, technology, engineering, math) or did not work in a virtual charter school. The data were also reviewed for any formatting errors from SurveyMonkey to Microsoft Excel. Next, the data were coded with numeric values representing variables and codes for questions and answers. The data codebook was saved in .xlsx format, readily usable for importing data into the SPSS statistical software. Finally, the cleaned and coded Excel spreadsheet was exported to SPSS for further data analysis.

Data Analysis and Results

The data analysis was completed using the most current version of SPSS software; Statistics Grad Pack V28 for Windows. The assumptions for using two-way ANOVA were tested before running a statistical analysis to determine if the data meets the requirements of the test. Laerd Statistics (year) stated the six assumptions for two-way ANOVA are: (a) independent variables measure at the continuous level; (b) the two independent variables should consist of two or more categorical, independent groups; (c) there should be independent of observations; (d) no significant outliers; (e) dependent variable should be approximately normally distributed for each combination of the groups of the two independent variables; and (f) homogeneity of variances (HOV) for each combination of the groups of the two independent variables (Laerd Statistics, 2018).

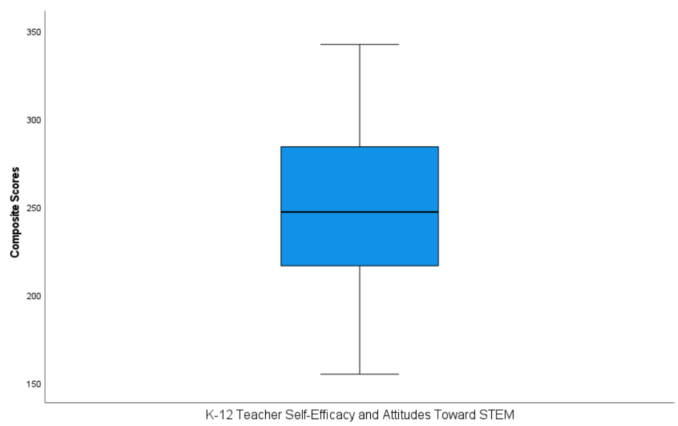
Three assumptions for using the two-way ANOVA were met before running the statistical tests in SPSS. First, the ordinal data from the Likert scale was treated as continuous, while the two-way ANOVA is robust and has tolerance to skewed data (De Winter & Dodou, 2010; Norman, 2010). Second, there are two independent variables, STEM subject matter and virtual teaching experience. The variables are categorical and have independent groups; subject area (elementary, science, technology, engineering, math) and virtual teaching experience (0–2 years, 2–5 years, and more than five years). Third, the independence of observation was met since the survey was anonymous and not influenced by other subjects. The SurveyMonkey surveys collected a numerical value, called IP addresses for each respondent. The IP addresses were reviewed to ensure no duplicate values were present in the data.

Assumptions Testing

The following three assumptions were tested for outliers, normal distribution, and homogeneity of variance. Outliers in the data set for the dependent variable, composite scores of teachers' self-efficacy and attitudes towards STEM was tested by a boxplot output in SPSS. The confidence interval was 95%. As shown in Figure 5, there are no outliers beyond the boxplot's whiskers.

Figure 5

Boxplot of Composite Self-efficacy and Attitudes Toward STEM



Note. Composite scores of self-efficacy and attitudes towards STEM.

Normal distribution was tested for the independent variables using the Shapiro-Wilk test in SPSS since the sample size was more than 50 participants. As shown in Table 4, the significance value, p, the subject matter is greater than the 0.05 alpha value. The Shapiro-Wilk test showed normality across the independent value of each subject; for example, science subject matter showed normality with W (24) = 0.9420, p = 0.181. A significance value higher than alpha confirms rejecting the null hypothesis stating the distribution is non-normal, concluding that our data has a normal distribution (Salkind, 2012). All subject matter areas showed normality, except for elementary subject matter, which significantly departed from normality *W* (39) = 0.088, p = 0.001.

Table 4

Normality Test Across Subject Matter

Subject Matter	Shapiro-Wilk		
	Statistic	df	Sig.
Elementary	0.888	39	0.001
Science	0.942	24	0.181
Technology	0.922	12	0.302
Engineering	0.928	9	0.461
Math	0.925	20	0.121

Note: * This is the lower bound of the true significance.

In Table 5, normality was found for teachers with 2–5 years and five or more years of virtual teaching experience, *D* (33) = 0.952, *p* = .148 and *W*(28) = .952, *p* = .219, respectively. The Shapiro-Wilk test showed non-normal distribution in the 0–2 year category of virtual teaching experience. Two-way ANOVA is a robust statistical test and can tolerate violations in normality in sample sizes greater than 5 or 10 per group (Norman, 2010). Table 3 included the frequency of respondents in each group. Pearson (1931) showed ANOVA being robust for both skewed and non-normal distributions with a sample size as small as 4.

Table 5

Normality Test across Years of Virtual Teaching Experience

Years' Experience	Shapiro-Wilk		
	Statistic	df	Sig.
0–2 years	0.923	43	0.007
2–5 years	0.952	33	0.148
5+ years	0.952	28	0.219

Note. *. This is a lower bound of the true significance.

The final assumption was homogeneity of variance (HOV) was tested by Levene's one–way *t*-test. As shown in Table 6, Levene's test showed that the variance for the subject matter was equal, F (4,104) = 0.635, p = .638. Therefore, the significant value of 0.638 is higher than the alpha value of 0.05, the variances are equal, and the null hypothesis is not rejected.

Table 6

Test of Homogeneity of Variance of Subject Matter

Composite Scores	Levene Statistic	df1	df2	Sig.
Based on Mean	0.635	4	99	0.638
Based on Median	0.537	4	99	0.709
Based on Median and with adjusted df	0.537	4	77.28	0.709
Based on trimmed mean	0.599	4	99	0.664

In Table 7, Levene's test showed that the variance for years of teaching experience online was not equal, F (2,101) = 5.281, p = .007. The significant value of 0.007 is lower than the alpha value of 0.5, HOV is unequal across groups. Due to unequal variances, a Welch test was conducted.

Table 7

Homogeneity of Variance of Years Virtual Teaching Experience

Composite Scores	Levene Statistic	df1	df2	Sig.
Based on Mean	5.281	2	101	0.007
Based on Median	3.871	2	101	0.024
Based on Median and with adjusted df	3.871	2	98.504	0.024
Based on trimmed mean	5.22	2	101	0.007

A Welch test is a robust test used to determine the equality of means when the data violates the assumption of homogeneity of variances. Field (2018) stated that Welch's test combats violations by adjusting F and the residual degrees of freedom to control Type I error rates (p. 443). The Welch test suggested that the difference between years of virtual teaching experience was insignificant F (2, 65.7) = 1.119, *p* = .333 (see Table 8).

Table 8

Welch's Test for Equal Means Across Years Virtual Teaching Experience

Composite Scores	Statistic[a]	df1	df2	Sig.
Welch	1.119	2	65.713	0.333

Note. a. Asymptotically F distributed.

The data collected by the survey had unequal variances and sample sizes across groups. In Table 9, Games-Howell post hoc showed all combinations of group differences without assuming equal variances and sample size. Each group showed non-significant values greater than $p>0.05$. Pallant (2020) stated that only those with a significance below $p<0.05$ are significantly different from each other (p. 267).

Table 9

Games-Howell Post-hoc Test for Virtual Teaching Experience

Dependent Variable:	Composite Scores						
(I) Years' Experience	(J) Years' Experience		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Games-Howell	0–2 years	2–5 years	10.573	11.065	0.607	–15.92	37.07
		5+ years	–5.076	9.77	0.862	–28.48	18.33
	2–5 years	0–2 years	–10.573	11.065	0.607	–37.07	15.92
		5+ years	–15.649	10.428	0.298	–40.74	9.44
	5+ years	0–2 years	5.076	9.77	0.862	–18.33	28.48
		2–5 years	15.649	10.428	0.298	–9.44	40.74

Note. Games–Howell showed all group means of years of experience as non–significant.

Research Question One determined if there is a statistically significant difference between teacher self-efficacy and attitudes towards STEM, as measured by the T-STEM survey when compared to the subject matter (science, technology, engineering, and math). The null hypothesis stated no statistically significant mean teacher self-efficacy and attitudes towards

STEM scores, as measured by the T-STEM survey between teachers who teach STEM subjects (science, technology, engineering, and math) in a virtual charter school in the United States. The data and statistical results were analyzed from the T-STEM survey data from 104 participants. The results were cleaned and coded and then run through two-way ANOVA testing. A statistically significant mean difference was identified between mean composite scores for teacher self-efficacy and attitudes towards STEM and subject matter, $F(4,89) = 20.302$, $p<0.001$. Therefore, the null hypothesis was rejected. The results indicated a main effect of subject matter on mean composite scores. The ANOVA summary is presented in Table 10.

Table 10

Test of Between–Subjects Effects

Dependent Variable:

Composite Scores

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	116035.548 a	14	8288.253	8.281	<.001
Intercept	3935057.658	1	3935057.658	3931.684	<.001
SubjectMatter	81277.411	4	20319.353	20.302	<.001
YearsExperience	12764.983	2	6382.492	6.377	0.003
SubjectMatter * YearsExperience	8129.288	8	1016.161	1.015	0.430
Error	89076.366	89	1000.858		
Total	6821125	104			
Corrected Total	205111.913	103			

Note. A. R Squared = .566 (Adjusted R Squared = .497)

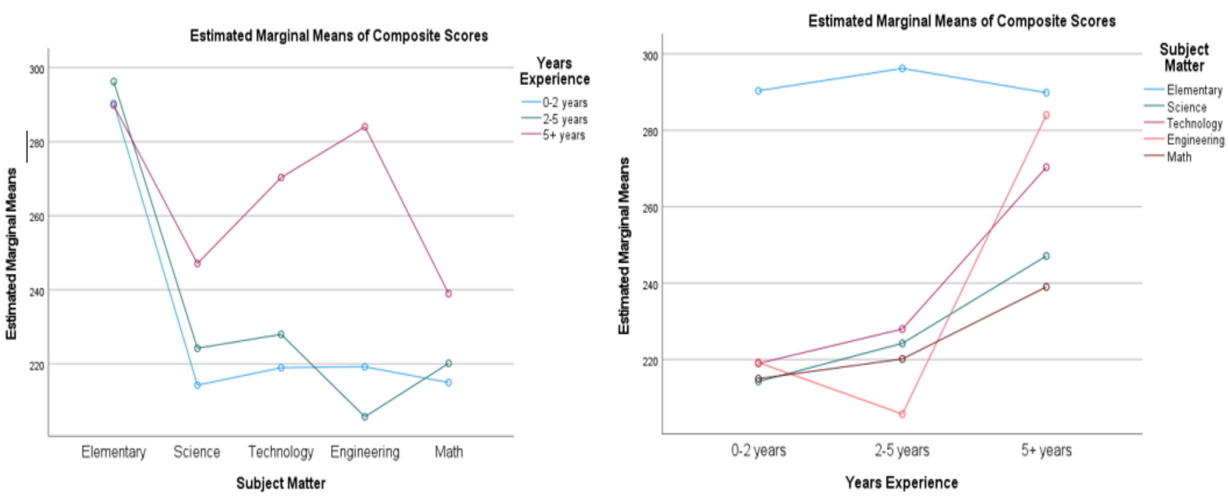
Research Question Two tested if there is a statistically significant difference between virtual teaching experience (categories of 0–2 years, 2–5 years, and more than five years) and teacher self-efficacy and attitudes towards STEM scores, as measured by the T-STEM survey from teachers in virtual charter schools in the United States. The null hypothesis stated that virtual teaching experience has no statistically significant mean difference in teacher self-efficacy and attitudes toward STEM scores, as measured by the T-STEM survey, between teachers' virtual teaching experience (categories 0–2 years, 2–5 years, and more than five years) in a virtual charter school in the United States. A two-way ANOVA was run on survey data for 104 participants who completed the electronic T-STEM survey. A statistically significant mean difference was identified between mean composite scores for teacher self-efficacy and attitudes towards STEM and virtual teaching experience, F (2,89) = 6.377, p=0.003. Therefore, the null hypothesis was rejected. There is a main effect of virtual teaching experience on composite scores. The ANOVA summary is presented in Table 10.

Research Question Three was tested to determine if there is a statistically significant interaction effect between subject matter (science, technology, engineering, and math) and virtual teaching experience (categories 0–2 years, 2–5 years, and more than five years) in virtual charter schools in the United States, in terms of teacher self-efficacy and attitudes towards STEM, as measured by T-STEM survey? The null hypothesis stated there is no statistically significant interaction effect between teachers who teach STEM subjects (science, technology, engineering, and math) and virtual teaching experience (categories 0–2 years, 2–5 years, and more than five years) in a virtual school in the United States in terms of teacher self-efficacy and attitudes toward STEM scores, as measured by the T-STEM survey. A two-way ANOVA was run on survey data for 104 participants who completed the electronic T-STEM survey. There is no statistically significant interaction of mean composite scores for teacher self-efficacy and attitudes towards STEM between subject matter and virtual teaching experience, F (8,89) = 1.015, p=0.430. The high p-value indicated noise in the data due to too much variation.

The marginal means of the T-STEM composite scores were analyzed to determine interaction effects for each group for the independent variables of subject matter and virtual teaching experience. Bryman and Cramer (2012) stated that the lines in an interaction-style plot would be approximately parallel when there are no interactions. As shown in Figure 6, the estimated marginal means of composite scores showed no interaction effect between subject matter and years of virtual teaching experience for most group comparisons. There are exceptions to the parallel lines, which show some interaction, evidenced by the disordinal lines. The interaction-style plot's varying slopes and disordinal lines may be attributed to statistical noise, such as sampling errors (Willard, 2020). The high p-value of 0.430 found in the tests of between-subject effects showed no statistically significant interaction.

Figure 6

Estimated Marginal Means of Composite Scores



Reliability and Validity

Based on the results from the ANOVA, both the mean composite scores across subject matter and years of virtual teaching experience were found to be statistically significant at $p<0.05$ at an effect size of 0.4 and power of 0.80. The T-STEM survey instrument was validated for reliability with a Cronbach's Alpha of 0.870 to 0.948. The internal consistency is met when Cronbach Alpha is more significant than 0.70 (Taber, 2018). An advantage of using an online data collection site such as SurveyMonkey was that the wording, directions, and design were simple and clear, which reduced any confusion or misunderstanding (Varela et al., 2016). Also, anonymous participation reduced any potential bias and the objectivity of the results.

External validity determines how the results generalize to other populations (Andrade, 2018). The three threats to external validity were the limitation of generalizability beyond the groups tested, the school setting, and the time the survey was completed. The survey was advertised on Facebook and LinkedIn to provide a large scope of participants based on teaching interests. Fourteen thousand eight hundred forty-four impression advertisements reached 9,421 people on Facebook, and 986 impressions were exposed to 429 people. The broad scope ensured the participation minimum of 92 teachers for a smaller subset of teachers that work virtually in the United States. The extensive reach would also provide data with the power of 0.80 and effect size of 0.4 with a confidence level of 95%.

The internal validity determines how well the study was conducted with the design, conduct, and analysis (Andrade, 2018). There are potential threats in this causal-comparative research design, such as non-random assignment, selection, maturation, and mortality (Creswell & Creswell, 2018). The threat of selection bias and outliers is higher in non-probability, convenience samplings methods such as purposive sampling (Etikan et al., 2016). The inclusion and exclusion criteria were used to help determine the correct data to include in the data analysis. The inclusion data included participants who teach elementary or secondary teachers in subject areas of science, technology, engineering, or math) in virtual charter schools located in the United States. A sampling selection technique was used to compare homogeneous subgroups clustered by a variable, controlling the sample and reducing counter threats to internal validity (Salkind, 2010). In this research, the independent variables of STEM subject area and virtual teaching experience were compared by subgroups to control each variable.

Chapter Summary

This quantitative study was casual–comparative to determine if there are group differences between subject matter and years of virtual teaching experience with composite scores on the T-STEM survey. The survey measures teachers' self-efficacy and attitudes in STEM subjects working full-time in virtual charter schools located in the United States. The first two research questions measured a difference in means across subject areas and then across years of virtual teaching experience. Based on the results from the ANOVA, both the mean composite scores across subject matter and years of virtual teaching experience were found to be statistically significant at $p<0.05$ at an effect size of 0.4 and power of 0.80. Research Question Three determined if there was a statistically significant interaction between subject matter and years of virtual teaching experience. The ANOVA showed a $p>0.05$ and no statistical significance between these two independent variables. A discussion of the findings and conclusions, alongside implications for further research, will follow in Chapter 5.

Chapter 5: Discussion and Conclusion

A higher self-efficacy may correlate with higher job satisfaction, teacher retention, and improved student performance (Chesnut & Burley, 2015; Demir, 2020; Larkin et al., 2018; Shahzad & Naureen, 2017). The quantitative causal-comparative study tested for statistically significant differences between STEM subject area teachers and virtual teaching experience (0–2 years, 2–5 years, and more than five years) in self-efficacy and attitudes towards STEM in the K–12 virtual setting. Teacher shortages and turnover have been apparent in subject areas such as math and science (Cross & Pollk, 2018). As of 2019, there were 297,712 students in full-time virtual charter schools across the United States (Molnar et al., 2019). School choice initiatives have contributed to the rise in non-traditional school settings (Cooper et al., 2020). Teachers must be prepared to support students online since not all skills are taught in teacher preparation programs, and not all traditional settings transfer over into online teaching. Many teachers may use their existing traditional teaching skillsets online (Moore-Adams et al., 2016).

The gap in the literature showed minimal research in teacher self-efficacy and attitudes towards STEM in the online learning environment. The research sought to determine any statistically significant differences in the STEM subject areas and virtual teaching experience in the virtual charter school setting. A causal-comparative research methodology was selected to determine existing statistical differences among STEM subject areas and virtual teaching experience. An existing instrument from Friday Institute was utilized to determine if there are any significant differences among groups.

Research Question One tested for statistically significant difference between STEM subject matter and teacher self-efficacy and attitudes towards STEM in virtual charter schools in the United States. The null hypothesis ($H1_o$) stated no statistically significant mean in teacher self-efficacy and attitudes towards STEM. A two-way ANOVA showed a statistically significant mean difference between mean composite scores for teacher self-efficacy and attitudes towards STEM and subject matter, F (4,89) = 20.302, p<0.001. The groupwise comparison test compared the variance in each group mean to the overall variance in mean composite scores. The null hypothesis for Research Question One was rejected. The alternative hypothesis ($H1_a$) was accepted at the $p < .05$ critical alpha level. The subject matter of science, technology, engineering, and math has a statistically significant mean difference in teacher self-efficacy and attitudes towards STEM, as measured by the T-STEM survey from teachers in virtual charter schools in the United States.

Research Question Two tested if there is a statistically significant difference between virtual teaching experience (categories of 0–2 years, 2–5 years, and more than five years) and teacher self-efficacy and attitudes towards STEM scores, as measured by the T-STEM survey from teachers in virtual charter schools in the United States. The null hypothesis ($H2_o$) stated that virtual teaching experience had no statistically significant mean difference in teacher self-efficacy and attitudes towards STEM. In Table 9, a Games–Howell post hoc test was used to test multiple comparisons. The groupwise comparison test compared the variance in each group mean to the overall variance in mean composite scores, F (2,89) = 6.377, p<0.001. The null hypothesis for Research Question Two was rejected. The alternative hypothesis ($H2_a$) was accepted at the $p < .05$ critical alpha level. Virtual teaching experience had a statistically significant difference in teacher self-efficacy and attitudes towards STEM.

Research Question Three tested for a statistically significant interaction effect between subject matter (elementary, science, technology, engineering, and math) and experience (0–2 years, 2–5 years, and more than five years) in teacher efficacy and attitudes in virtual charter schools in the United States. The null hypothesis ($H3_o$) stated no statistically significant interaction effect between teachers who teach STEM subjects (science, technology, engineering, and math) and virtual teaching experience (categories 0–2 years, 2–5 years, and more than five years) in a virtual school in the United States in terms of teacher self-efficacy and attitudes toward STEM scores, as measured by the T-STEM survey, $F(8,89) = 1.015$, $p<0.430$. The alternative hypothesis ($H3_a$) was accepted at the $p < .05$ critical alpha level. The subject matter and virtual teaching experience have a statistically significant positive interaction on teacher self-efficacy and attitudes in STEM, as measured by the T-STEM survey from teachers in virtual charter schools in the United States.

The following chapter includes the findings, interpretations, and conclusions related to the research questions and theoretical framework. A discussion regarding the findings related to research will follow. Next, limitations will be shared to share the context and challenges of the study. Finally, recommendations and implications for leadership will conclude the discussion related to the findings.

Findings, Interpretations, Conclusions

The findings from the study provide causal-comparative research on science, technology, engineering, and math instruction in the online virtual charter school setting. Causal-comparative research helps determine a significant statistical difference among the independent variables of subject matter and virtual teaching experience on the dependent variable of teacher self-efficacy and attitudes towards STEM. In addition, the findings of a causal-comparative research design will determine if either of the independent variables affects the dependent variable (Salkind, 2010).

Findings Related to the Literature

Studies have established that teacher self-efficacy is linked positively to job satisfaction, job retention, and student achievement (Chesnut & Burley, 2015; Demir, 2020; Larkin et al., 2018; Shahzad & Naureen, 2017). Correlational research by Demir (2020) found that self-efficacy and job satisfaction were positively correlated in the traditional middle school setting. More so, meta-studies from 102 independent data further showed a positive linear relationship, R = 0.28 (Kasalak & Dağyar, 2020). Earlier studies show that job stress predicts stress and teacher burnout (Schwarzer & Hallum, 2008). Job retention has also been studied with teacher self-efficacy. Renbarger and Davis (2019) show a lower attrition rate for teachers with a positive relationship with self-efficacy. In the research literature, student achievement is related to teacher self-efficacy. Quantitative research with 60 Pakistani teachers revealed that teachers' perceptions of self-efficacy are positively correlated to student academic achievement (Shahzad & Naureen, 2017).

Studies on self-efficacy show how mastery and vicarious experience can impact a teacher's perceptions of self-efficacy (Barton & Dexter, 2020; McKim & Velez, 2016). Self-efficacy can improve and change over time. Gallagher (2012) found that struggling teachers may not have enough support and positive experiences with teaching. Servant leadership is an option for educational settings where leaders focus on the professional growth of their staff. A study by Wu et al. (2020) showed that teachers' perception of their schools' leadership as being a servant has a lower level of attrition and stress.

Studies show that teachers who transition face-to-face to online need additional skills to succeed (Esani, 2010; Gloria & Uttal, 2020). While some skills transfer over, new skills such as course designer, manager, coach, and resource manager need to be developed. Furthermore, Beck and Beasley (2020) showed that K–12 virtual schoolteachers had a beginning level for differentiation, assessment, curriculum, and strategies in the online setting. Studies suggest that teachers have professional development at the intersection of pedagogy and technological knowledge. Teacher support and professional development in technological, pedagogical, and content knowledge (TPACK), online teaching standards, Universal Design for Learning (UDL), and Web 2.0 tools are common themes in online teaching. Servant leaders can support teachers by providing time and opportunities to increase strategies and best practices in virtual charter schools.

Bandura (1997) proposed that four states may improve a teachers' self-efficacy: master experiences, vicarious experiences, verbal persuasion, and emotional states. Mastery and vicarious experiences can be included in the virtual charter school setting. Dos Santos (2020) found that STEM teachers could increase their pedagogical development through peer observations. Additionally, mastery experience can be aided by additional practice, coaching, or getting an advanced degree. Engaging with peers, mentors, or formal professional development substantially affects teaching self-efficacy (Phuong, 2017; Tschannen-Moran & McMaster, 2009). Verbal persuasion can be developed by either the servant leader or peer interactions. Wright et al. (2019) found that new STEM teachers' mentors and communities of practice develop ongoing support and resiliency. By providing opportunities for professional growth, teachers may gain positive experiences regarding online teaching and STEM instruction, which increase the emotional states that impact teaching self-efficacy (Phuong, 2017).

Studies show that formal teacher preparation programs can increase teachers' confidence and self-efficacy (Gurley, 2018; Larson & Archambault, 2019). Formal training programs where teachers have field experience have also aided pre-service teachers by offering opportunities for shadowing of K–12 virtual schoolteachers (Luo et al., 2017). Professional development can be successful in-service days with vicarious and mastery experience through peer observation and mentorship. Lee et al. (2020) found that online community aids online professional development. The study included a statistics professional development session that also provided an online community that enabled teachers to discuss, analyze student work, collaborate on problem-based scenarios, which helps increase confidence in teaching.

While studies have been prevalent for teacher self-efficacy in the traditional setting, minimal research has been conducted among STEM subject matter teachers in the virtual charter school setting. The T-STEM survey results found that STEM subject matter and virtual teaching experience are statistically different for mean composite self-efficacy and attitudes towards STEM scores. However, the analysis found no statistically significant interaction between STEM subject matter and virtual teaching experience.

Interpretation of Findings and Conclusions

The findings from the research confirm, disconfirm, and extend the current knowledge of teacher self-efficacy research and attitudes towards STEM in the virtual charter school setting. Data interpretation follows with an analysis in the context of the theoretical framework. Finally, conclusions will culminate the interpretation and remain within the study's scope.

Subject Matter

Current research showed that subject matter plays a factor in teacher self-efficacy. Lee et al. (2019) found significant differences in teacher self-efficacy scores across science, technology, and math subjects in the traditional school setting. This research study showed that teachers' self-efficacy and attitudes towards STEM for science, technology, engineering, and math for grades 6–12 were significantly lower in mean composite scores than elementary mean composite scores. All other secondary subject matter was within 15 points, with the standard deviation of 44.62, for mean composite scores for the 6–12 grade (science, technology, engineering, math). These findings suggest that more professional preparation is needed for secondary STEM teachers in the online setting when compared to elementary teachers.

Teaching STEM areas in virtual charter schools provide more teaching challenges when the content becomes specialized, like secondary education. While some research showed that virtual laboratories could simulate hands-on learning, others say they are ineffective (Lewis, 2014). Students reach secondary grade levels with more granular and specific content, resulting in the virtual labs' user experience looking similar but having limited experimental conditions (Keller, 2021). At the secondary level, students may need more natural conditions to experiment to understand the various effects of the tested variables. Davis and Pinedo (2021) confirmed the challenges of online labs in anatomy and physiology courses, stating that hands-on dissections provided collaborative learning and improved understanding of human anatomy. Online teachers will need to understand the deficiencies of technology tools to support any gaps and extend students' understanding. Lewis (2014) posited that virtual labs could prepare traditional labs or vice versa. While the online setting may not allow for a traditional lab, synchronous demonstrations and discussions may be viable options following a virtual lab.

For many students, hands-on activities such as manipulatives are essential for understanding content. Virtual manipulatives have increased in popularity in traditional and online learning environments in the last decade. Some studies share that virtual manipulatives are as effective in the online environment as in traditional settings (Cavanaugh et al., 2008; Oymak & Ogan-Bekiroglu, 2021). While there is an increase in virtual tools being utilized in education, barriers affect a teachers' ability to integrate technology into the pedagogy. Hsu (2016, p. 37) shared that the barriers for technology integration are students' lack of computer skills and teachers' lack of training and exposure to technology, technical support, and time to implement technology-integrated lessons. STEM content instructional practices should focus on connecting across STEM disciplines, using real-world, inquiry-based, engineering design, cooperative learning, student-centered, and hands-on problems with authentic assessments and usage of 21st-century skills (Thibaut et al., 2018). If a teacher is not prepared for teaching in the online setting, the variety of tools, simulations, labs, and manipulatives may be used minimally or ineffectively.

An educator should adapt traditional instructional learning methods, such as laboratories and manipulatives, to the online environment, in addition to pedagogical practices, best practices for technology usage, and integration with content knowledge skills specific to online teaching. Technological, pedagogical, and content knowledge (TPACK) integration can be developed using the TPACK framework (Archambault & Crippen, 2009; Kennedy, 2015). Studies of online teachers found that the highest levels in the TPACK framework were in pedagogy, content, and pedagogical content (Archambault & Crippen, 2009). In addition, teachers' rating levels dropped when pedagogy and content were combined with technological knowledge. Additional studies by Bakar et al. (2020) affirm that mathematics teaching self-efficacy with technology integration is strongly associated with using a TPACK framework. Therefore, professional development is warranted, focusing on subject matter and technology tools to improve confidence and teaching self-efficacy online.

Virtual Teaching Experience

Current research on the impact of years of online teaching experience in the virtual charter school setting is minimal. However, Swan et al. (2011) found that teachers in the traditional setting showed a higher level of self-efficacy after student teaching, dropping after the first year, rising the second year, and then decreasing again after the third year of teaching. The research data findings from this study confirm that overall virtual teaching experience impacts composite self-efficacy and attitudes towards STEM in a non-linear progression. Furthermore, this study showed a non-linear means for composite scores compared to virtual teaching experience. These findings suggest that professional development and online teaching preparation are higher for virtual charter school STEM teachers with 0–2 and five or more years of virtual teaching experience.

Data showed that the teachers in K–12 STEM subject areas in virtual charter schools showed the highest mean composite scores for five or more years of virtual teaching experience. Research showed that self-efficacy and professional development strongly correlate positively (Yang, 2020). Virtual teachers that have been teaching in this context for five or more years have more experience in the online environment. State requirements for renewal of teacher credentials vary by state, but most require professional development and continuing education units (Darling-Hammond et al., 2018). For recertification of a teaching credential, clock hours or credits must be verified. In states with these requirements, the more years of teaching experience you have, the more opportunities for professional development would be required.

Respondents with 0–2 years of virtual teaching experience had higher mean composite scores than those with 2–5 years of experience but not more than those who have been virtually teaching five or more years. As virtual teaching expands nationally, teacher preparation programs need to evolve to focus more on online education. A survey from 2016 shared that only four percent of respondents had experience with student teaching in K–12 online settings (Koenig, 2020). ASU Prep Digital online charter school, collaborated with Arizona State University in 2019 to create a pilot program to help bridge the preparation gap for online teachers (Basile, 2022). The free program offers professional development where teachers can learn about strategies and best practices for online learning and teaching.

Before the COVID-19 pandemic, there was very little preparation and focus on teacher preparation programs towards teaching online education. In this study, the teacher self-efficacy and attitudes towards STEM dropped in composite scores between two to five years of virtual teaching experience. With only four percent of respondents getting student teaching experience with K–12 online settings in 2016, many teachers in this category had minimal preparation or enough professional development to increase self-efficacy in teaching online.

Interaction Effect Among Subject Matter and Virtual Teaching Experience

The findings showed no statistically significant interaction between subject matter and virtual teaching experience among mean composite scores for teacher self-efficacy and attitudes towards STEM in the United States K–12 virtual charter school setting. An interaction effect between subject matter and years of virtual teaching experience could not be demonstrated. This study suggests that personal and contextual factors impact teaching self-efficacy and attitudes towards STEM (Barni et al., 2019; Xie et al., 2021).

This research study was a national survey providing individual, regional, and contextual internal and external barriers factoring into the mean composite scores of teachers' self-efficacy levels and attitudes towards STEM. For example, personal values such as conservation of tradition, conformity, and security positively correlate with self-efficacy (Barni et al., 2019). Conservation values seek to limit conflict and maintain current order (Schwartz, 2012). In contrast, Poulou (2007) found in a study of self-reported surveys that personality (positive stance and direct communication with students) and motivation factors (love for pupils and desire to improve the teaching task) showed higher teacher self-efficacy in pre-service student teachers.

Xie et al.'s (2021) research showed internal and external barriers to integrating digital education resources. This research study's lack of interaction may be due to external factors such as lack of resources, support, instructional strategies, and institutional vision, all of which are contextual. Internal barriers can vary from teacher to teacher and include knowledge, skills, and beliefs about integrating technology into the curriculum. Xie et al. (2021) posited that internal barriers are more rigid and can be a more challenging factor when implementing technology into the curriculum but can be improved with professional development.

Relationship Between Teacher Self-efficacy and Servant Leadership

In the traditional setting, teacher self-efficacy was related to years of teaching experience and teaching level (Klassen & Chiu, 2010). In addition, self-efficacy is believed to be non-static and may change based on personal and contextual factors. Teachers have varying self-efficacy and attitudes towards STEM, depending on the subject matter taught and their number of years of virtual teaching experience. This study confirms significant statistical differences across both subject matter and years of virtual teaching experience. Current research showed that teachers with high perceptions of self-efficacy are more effective and take advantage of professional development opportunities (Bolshakova et al., 2011).

Self-efficacy theory states that mastery experiences, vicarious experiences, verbal persuasion, and emotional states can improve and increase self-efficacy (Bandura, 1997). STEM subject matter teachers in grades 6–12th grade showed lower self-efficacy and attitudes towards STEM and may need more support when implementing their subject in the online setting. Variations may also focus on online teaching readiness based on years of virtual experience in teacher preparation programs. In this research study, teachers with 2–5 years of virtual teaching had the lowest mean composite scores for self-efficacy and attitudes towards STEM. This study extends the knowledge by sharing that there are more confounding variables beyond teachers' subject areas and years of virtual teaching experience. Personal and contextual factors and online teaching preparation may play a factor in a teachers' self-efficacy.

Consistent with self-efficacy theory and Servant leadership theory research, professional development should focus on training based on the needs of the individual teachers. With varying levels of teacher self-efficacy and attitudes towards STEM, professional development will need to be customized to the areas of need based on survey score results from the T-STEM survey. Servant leaders can use the information from this study to support teacher professional development on technological, pedagogical, and content knowledge for the online setting. Virtual charter school servant leaders may provide time and resources for professional development and ongoing support for STEM subject matter teachers. A focus on professional development may provide opportunities for increased teacher self-efficacy in the K–12 virtual charter school setting. Higher self-efficacy affects job satisfaction, job retention, and student achievement (Chesnut & Burley, 2015; Demir, 2020; Larkin et al., 2018; Shahzad & Naureen, 2017).

Limitations of the Study

The participants for this research study were those willing to participate in the survey and are currently working in a K–12 virtual charter school in the United States. The participants also had to have been in the subject matter areas of elementary, science, technology, engineering, or math. The survey had a qualifying demographics section before respondents could proceed to any survey questions to ensure recruitment was for the intended population. Only those respondents that met the inclusion requirements of the study were able to participate.

Limitations to internal validity were a lack of random sampling and the inability to manipulate the independent variable (Salkind, 2010). The independent variable cannot be manipulated because the participants were already exposed to teaching in the STEM subject area and virtual teaching experience before the survey. There are also limitations to survey data due to the participants' perceived time constraints, resulting in hurried responses or non-participation (Tuckman & Harper, 2012). Self-reported data are also a limitation and cannot verify for exaggeration or underestimation of teachers' perceived self-efficacy. In addition, the T-STEM survey also had finite response categories compared to an open-ended interview where respondents can have a wide range of responses.

Confounding variables are online teaching preparation programs and professional development teachers have previously taken in advance of this study. Additionally, personal factors such as cognitive, affective, biological factors, environmental factors such as genetics, and influences of culture, social support, or situational characteristics may also affect teachers' self-efficacy levels (Burke et al., 2009). Confounding variables and personal factors were not included in this research.

Limitations to external validity were generalizability beyond the groups tested, the school setting, and the time. Limitations in exploratory studies, such as causal-comparative research, cannot be conclusive until results are repeated (Queirós et al., 2017). Recruitment on only social media groups of Facebook and LinkedIn also threatens the external validity of generalizability. The generalizability of this study applies to the participants that were willing to participate in this study that met the inclusion criteria for being K–12 virtual charter school teachers in the United States, specifically teaching elementary, science, technology, engineering, and math subjects.

Reliability of the survey showed in previous settings internal consistency, with a

Cronbach's Alpha of 0.870 to 0.948 for the T-STEM survey. According to Taber (2018), internal consistency is met when the value is higher than 0.70. The survey instrument was found to be reliable, strong, and had excellent descriptor categories. Mitigation of confusion was aided by survey directions and questions being transcribed into the electronic survey as they were initially developed.

Recommendations

Virtual charter schools in the United States have increased as an alternative educational option in the K–12 sector. Concerning school choice, charters schools have been one of the fastest-growing areas for alternative education (Berends, 2021). As of 2019, there are 297,712 students in full-time virtual charters schools (Molnar et al., 2019). Leaders of virtual charters schools will need to ensure that their teachers are prepared to teach and support students online. In addition, they may offer professional development opportunities to increase teaching self-confidence in the online setting. Professional development may be offered informally and formally inside and outside the school setting.

Leaders of virtual charter schools may note the trends in online learning and their staff's education in their teacher preparations programs. There may be trends of an increasing amount of preparation in virtual teaching, which may vary by school, degree, or years of prior experience online. Leaders may want to offer professional development opportunities, onboarding training programs, or recruit virtual teachers with pre-existing online teaching skills. Leaders can survey their staff or hiring prospects to determine their online teaching proficiencies. Leaders should support gaps in the various skills needed to succeed in the virtual charter school setting.

An educator will want to adapt traditional learning methods to the online environment and pedagogical practices, best practices for technology usage, and integration with content knowledge skills specific to online teaching. Technological, pedagogical, and content knowledge (TPACK) integration can be developed using the TPACK framework (Archambault & Crippen, 2009; Kennedy, 2015). Teaching skills specific to online instruction, such as course designing, organization, and management, are additional topics that should be offered as part of professional development (Esani, 2010; Gloria & Uttal, 2020).

Recommendations for further studies may include a larger sample size that includes random sampling strategies. In addition, longitudinal studies of K–12 virtual charter schoolteachers in elementary, science, technology, engineering, or math subject matter areas will show teacher self-efficacy and attitudes towards STEM over time. Experimental research is recommended to determine if there is an increase in teacher efficacy and attitudes towards STEM after professional development. Virtual charter schools should survey teachers' needs for teaching in the online setting and then offer professional development before or concurrently when a newly hired employee starts working at their virtual charter school.

Implications for Leadership

Servant leaders can help increase teachers' self-efficacy perceptions in teaching (Demir, 2020). Mastery experiences, vicarious experiences, verbal persuasion, and emotional states contribute to self-efficacy (Bandura, 1997). Higher self-efficacy can lead to factors that may provide for more job satisfaction, teacher retention, and increased student achievement. Leaders should offer a variety of opportunities for professional development both internally with colleagues and externally through formal courses, professional development, and the usage of professional learning networks.

Methodological implications for future researchers are to get a larger sample size that includes a variety of snowball targeting and purposive sampling across various virtual charter schools in the United States. While convenience sampling is inexpensive and convenient, the generalizability of the data is limited to the study (Salkind, 2010). A variety of STEM-based schools could inform the effectiveness of any professional development that increases teacher self-efficacy. Leadership and research can employ experimental studies with pre- and post-tests after online teaching professional development opportunities for science, technology, engineering, and math classes. The post-tests will show the success of the professional development on teacher efficacy and attitudes towards STEM.

This research study showed varying teacher self-efficacy and attitudes towards STEM in K–12 virtual charter schools in the United States subject areas of elementary, science, technology, engineering, and math. There are a variety of skills that online teachers need, which may vary across subject matter and years of virtual teaching experience (Esani, 2010; Gloria & Uttal, 2020). Empirical implications for leadership could be to provide a survey of their staff to determine areas of improvement and growth opportunities. Leadership may provide the time, resources, and opportunities for development in teachers' areas of need.

Conclusion

Self-efficacy for teaching can be strengthened by professional development through highly effective modalities of mastery and vicarious experiences (Barton & Dexter, 2020). The Servant leadership theory empowers and strengthens teachers to grow professionally. Mastery experiences, vicarious experiences, verbal persuasion, and emotional states help teachers achieve higher self-efficacy (Gallavan, 2017). K–12 virtual charter schoolteachers from the United States significantly differ in their self-efficacy and attitudes towards STEM. The mean composite scores on the T-STEM show variance by subject matter (elementary, science, technology, engineering, and math) and years of virtual teaching experience. Leadership may offer opportunities to learn and reflect on best practices for teaching in the online setting. Professional development may occur in various formats, such as in-service, professional conferences, mentoring, professional learning communities and networks, and coaching. Focus on increasing self-efficacy in STEM subject areas can include skills needed to transition to online teaching, standards and best practices for teaching online, online pedagogy and instructional practices, technological, pedagogical, and content knowledge (TPACK), and Web 2.0 tools. Higher self-efficacy correlates to job satisfaction, commitment to the profession, and student performance (Chesnut & Burley, 2015; Demir, 2020; Larkin et al., 2018; Shahzad & Naureen, 2017). Leadership may help support the growth of self-efficacy by providing opportunities for professional development on best practices and trends in online teaching.

References

Adelstein, D., & Barbour, M. (2016). Building better courses: Examining the construct validity of the iNACOL national standards for quality online courses. *Journal of Online Learning Research*, *2*(1), 41–73. Association for the Advancement of Computing in Education (AACE). https://digitalcommons.sacredheart.edu/

Adnan, M. (2018). Professional development in the transition to online teaching: The voice of entrant online instructors. *ReCALL, 30*(1), 88–111. https://doi.org/10.1017/s0958344017000106

Adom, D., Hussein, E. K., & Agyem, J. A. (2018). Theoretical and conceptual framework: Mandatory ingredients of a quality research. *International Journal of Scientific Research*, *7*(1), 438–441. https://doi.org/10.36106/ijsr

Afaq, A., Sajid, M. A., & Arshad, A. (2017). Examining the impact of servant leadership on teachers' job satisfaction. *Pakistan Business Review*, *18*(4), 1031–1047. https://pbr.iobm.edu.pk/

Alhassan, R. (2017). Exploring the relationship between Web 2.0 tools self-efficacy and teachers' use of these tools in their teaching. *Journal of Education and Learning*, *6*(4), 217–228. https://doi.org/10.5539/jel.v6n4p217

Allen, M. (Ed.). (2017). *The SAGE encyclopedia of communication research methods*. (Vol. 3, pp. 1295 –1296). SAGE Publications. https://doi.org/10.4135/9781483381411.n447

Andrade, C. (2018). Internal, external, and ecological validity in research design, conduct, and evaluation. *Indian journal of psychological medicine, 40*(5), 498–499. https://doi.org/10.4103%2FIJPSYM.IJPSYM_334_18

Archambault, L., & Crippen, K. (2009). Examining TPACK among K–12 online distance educators in the United States. *Contemporary Issues in Technology and Teacher Education*, *9*(1), 71–88. https://citejournal.org/

Ashton, J. (2014). Barriers to implementing STEM in K–12 virtual programs. *Distance Learning, 11*(1), 51–57. https://www.infoagepub.com/distance–learning.html

Bakar, N. S. A., Maat, S. M., & Rosli, R. (2020). Mathematics teacher's self-efficacy of technology integration and technological pedagogical content knowledge. *Journal on Mathematics Education*, *11*(2), 259–276. https://doi.org/10.22342/jme.11.2.10818.259-276

Baldwin, S. J., & Ching, Y. H. (2019). Online course design: A review of the Canvas course evaluation checklist. *International Review of Research in Open and Distributed Learning, 20*(3), 269–282. https://doi.org/10.19173/irrodl.v20i3.4283

Bal–Taştan, S., Davoudi, S. M. M., Masalimova, A. R., Bersanov, A. S., Kurbanov, R. A., Boiarchuk, A. V., & Pavlushin, A. A. (2018). The impacts of teacher's efficacy and motivation on student's academic achievement in science education among secondary and high school students. *Eurasia Journal of Mathematics, Science and Technology Education*, *14*(6), 2353–2366. https://doi.org/10.29333/ejmste/89579

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

Bandura, A. (1984). Recycling misconceptions of perceived self–efficacy. *Cognitive Therapy and Research, 8*(3), 231–255. https://doi.org/10.1007/bf01172995

Bandura, A. (1997). *Self–efficacy: The exercise of control*. Worth Publishers.

Barni, D., Danioni, F., & Benevene, P. (2019). Teachers’ self–efficacy: The role of personal values and motivations for teaching. *Frontiers in Psychology*, *10*, Article 1645. https://doi.org/10.3389/fpsyg.2019.01645

Barton, E. A., & Dexter, S. (2020). Sources of teachers' self-efficacy for technology integration from formal, informal, and independent professional learning. *Educational Technology Research and Development*, *68*(1), 89–108. https://doi.org/10.1007/s11423–019–09671–6

Basile, C. G. (2022). Arizona State University: A learning enterprise supporting P–12 education in the COVID-19 pandemic. In F. M. Reimers & F. J. Marmolejo (Eds.), *University and school collaborations during a pandemic: Sustaining educational opportunity and reinventing education*, (pp. 287–297). Springer, Cham. https://doi.org/10.1007/978–3–030–82159–3_19

Beck, D., & Beasley, J. (2020). Identifying the differentiation practices of virtual school teachers. *Education and Information Technologies*, 1–15. https://doi.org/10.1007/s10639–020–10332–y

Beck, D., Maranto, R., & Shakeel, M. D. (2016). Does rural differ? Comparing parent and student reasons for choosing cyber schooling. *Rural Educator*, *37*(3), 1–16. https://doi.org/10.35608/ruraled.v37i3.243

Berends, M. (2021). The current landscape of school choice in the United States. *Phi Delta Kappan*, *103*(1), 14–19. https://doi.org/10.1177/00317217211043619

Bergman, P., & McFarlin, I., Jr. (2018, December). *Education for All? A nationwide audit study of school choice* (NBER Working Paper No. w25396). https://doi.org/10.3386/w25396

Bhowmik, M., Banerjee, B., & Banerjee, J. (2013). Role of pedagogy in effective teaching. *Basic Research Journal of Education Research and Review*, *2*(1), 1–5. https://doi.org/10.33495%2Fjerr

Biernacki, P., & Waldorf, D. (1981). Snowball sampling: Problems and techniques of chain referral sampling. *Sociological Methods & Research*, *10*(2), 141–163. https://doi.org/10.1177/004912418101000205

Bolatli, Z., & Korucu, A. T. (2018). Secondary school students' feedback on course processing and collaborative learning with web 2.0 tools–supported STEM activities. *Bartın Üniversitesi Eğitim Fakültesi Dergisi*, *7*(2), 456–478. https://doi.org/10.14686/buefad.358488

Bolshakova, V. L. J., Johnson, C. C., & Czerniak, C. M. (2011). “It depends on what science teacher you got”: urban science self-efficacy from teacher and student voices. *Cultural Studies of Science Education*, *6*(4), 961–997. https://doi.org/10.1007/s11422–011–9346–2

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

Brinson, J. R. (2017). A further characterization of empirical research related to learning outcome achievement in remote and virtual science labs. *Journal of Science Education and Technology*, *26*(5), 546–560. https://doi.org/10.1007/s10956–017–9699–8

Bryman, A., & Cramer, D. (2012). *Quantitative data analysis with IBM SPSS 17, 18 & 19: A guide for social scientists*. Routledge. https://doi.org/10.4324/9780203180990

Buonomo, I., Fiorilli, C., & Benevene, P. (2019). The impact of emotions and hedonic balance on teachers' self–efficacy: Testing the bouncing back effect of positive emotions. *Frontiers in Psychology*, *10*, Article 1670. https://doi.org/10.3389/fpsyg.2019.01670

Burke, N. J., Bird, J. A., Clark, M. A., Rakowski, W., Guerra, C., Barker, J. C., & Pasick, R. J. (2009). Social and cultural meanings of self–efficacy. *Health Education & Behavior*, *36*(5_suppl), 111S–128S. https://doi.org/10.1177/1090198109338916

Cavanaugh, C., Gillan, K. J., Bosnick, J., Hess, M., & Scott, H. (2008). Effectiveness of interactive online algebra learning tools. *Journal of Educational Computing Research, 38*(1), 67–95. https://doi.org/10.2190/EC.38.1.d

Cavanaugh, C., & Roe, M. (2019). Developing pedagogy and course design skills in novice virtual school teachers in Australia. *Journal of Online Learning Research*, *5*(1), 5–22. https://www.aace.org/pubs/jolr/

Chai, C. S., Jong, M., Yin, H. B., Chen, M., & Zhou, W. (2019). Validating and modelling teachers' technological pedagogical content knowledge for integrative science, technology, engineering and mathematics education. *Journal of Educational Technology & Society*, *22*(3), 61–73. https://www.j-ets.net/

Chen, B., Bastedo, K., & Howard, W. (2018). Exploring design elements for online stem courses: Active learning, engagement & assessment design. *Online Learning*, *22*(2), 59 – 75. https://olj.onlinelearningconsortium.org/index.php/olj/index

Chesnut, S. R., & Burley, H. (2015). Self-efficacy as a predictor of commitment to the teaching profession: A meta-analysis. *Educational Research Review, 15*, 1–16. https://doi.org/10.1016/j.edurev.2015.02.001

Chingos, M. M., & West, M. R. (2015). The uneven performance of Arizona's charter schools. *Educational Evaluation and Policy Analysis*, *37*(1_suppl), 120S–134S. https://doi.org/10.3102/0162373715576077

Choo, L. M. (2020). Web 2.0 in secondary science instruction: Assessing teachers' self-efficacy and integration level and the relationship between them. *Learning Science and Mathematics*, 84–101. http://www.recsam.edu.my/sub_lsmjournal/

Clark, M. A., Gleason, P. M., Tuttle, C. C., & Silverberg, M. K. (2015). Do charter schools improve student achievement? *Educational Evaluation and Policy Analysis*, *37*(4), 419–436. https://doi.org/10.3102%2F0162373714558292

Clark, S., & Newberry, M. (2019). Are we building pre–service Teacher self–efficacy? A large–scale study examining Teacher education experiences. *Asia–Pacific Journal of Teacher Education*, *47*(1), 32–47. https://doi.org/10.1080/1359866X.2018.1497772

Cochran, W. G. (1977). *Sampling techniques* (3rd ed.). John Wiley & Sons.

Cohen, J. (2013). *Statistical power analysis for the behavioral sciences*. Academic Press.

Commission on Teacher Credentialing. (2017, May 10). *Charter schools*. https://www.ctc.ca.gov/employers/charter–schools#:~:text=Since%20January%201%2C%201999%2C%20all,the%20Commission%20on%20Teacher%20Credentialing

Cong, L. M. (2020). Successful factors for adoption of synchronous tools in online teaching at scale. In T. McLaughlin, A. Chester, B. Kennedy, & S. Young (Eds.), *Tertiary education in a time of change: Disruptions, challenges and strategies.* (pp. 39–60). Springer. https://doi.org/10.1007/978–981–15–5883–2_4

Cooper, R., Farah, A., & Mrstik, S. (2020). Preparing teacher candidates to teach online: A case study of one college's design and implementation plan. *International Journal on E-Learning, 19*(2), 125–137. https://www.aace.org/pubs/ijel/

Corry, M., & Stella, J. (2018). Teacher self-efficacy in online education: A review of the literature. *Research in Learning Technology, 26*. 1–12. https://doi.org/10.25304/rlt.v26.2047

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). SAGE Publications.

Creswell, J. W., & Guetterman, T. (2019). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (6th ed). Pearson.

Crippen, C., & Willows, J. (2019). Connecting teacher leadership and servant leadership: A synergistic partnership. *Journal of Leadership Education, 18*(2), 171–180. https://doi.org/10.12806/v18/i2/t4

Cross, T., & Pollk, L. (2018). Burn bright, not out: Tips for managing online teaching. *Journal of Educators Online*, *15*(3), 1–6. https://doi.org/10.9743/jeo.2018.15.3.1

Dalton, E. M. (2017). Universal design for learning: Guiding principles to reduce barriers to digital & media literacy competence. *Journal of Media Literacy Education*, *9*(2), 17–29. https://doi.org/10.23860/JMLE–2019–09–02–02

Darling–Hammond, L., Sutcher, L., & Carver–Thomas, D. (2018). *Teacher shortages in California: Status, sources, and potential solutions*. Learning Policy Institute. https://learningpolicyinstitute.org/product/teacher–shortages–ca–solutions–brief

Davis, C. P., & Pinedo, T. (2021). The challenges of teaching anatomy and physiology laboratory online in the time of COVID-19. *Journal of Microbiology & Biology Education*, *22*(1), 1–4. https://doi.org/10.1128/jmbe.v22i1.2605

de Winter, J. F. C., & Dodou, D. (2010). Five-point Likert items: t-test versus Mann-Whitney-Wilcoxon (addendum added October 2012). *Practical Assessment, Research, and Evaluation*, *15*(1), 11–16. https://doi.org/10.7275/bj1p–ts64

DeBoer, J., Haney, C., Atiq, S. Z., Smith, C., & Cox, D. (2019). Hands-on engagement online: Using a randomized control trial to estimate the impact of an at-home lab kit on student attitudes and achievement in a MOOC. *European Journal of Engineering Education*, *44*(1–2), 234–252. https://doi.org/10.1080/03043797.2017.1378170

Demir, S. (2020). The role of self-efficacy in job satisfaction, organizational commitment, motivation and job involvement. *Eurasian Journal of Educational Research*, *20*(85), 205–224. https://doi.org/10.14689/ejer.2020.85.10

Deng, F., Chai, C. S., So, H. J., Qian, Y., & Chen, L. (2017). Examining the validity of the technological pedagogical content knowledge (TPACK) framework for preservice chemistry teachers. *Australasian Journal of Educational Technology*, *33*(3), 1–14. https://doi.org/10.14742/ajet.3508

Dos Santos, L. M. (2020). Pre-service teachers' pedagogical development through the peer observation professional development programme. *South African Journal of Education*, *40*(3), 1–12. https://doi.org/10.15700/saje.v40n3a1794

Epple, D., Romano, R., & Zimmer, R. (2016). Chapter 3-charter schools: A survey of research on their characteristics and effectiveness. In E. A. Hanushek, S. Machin, & L.

Woessmann (Eds.), *Handbook of the Economics of Education* (Vol. 5, pp. 139–208). Elsevier. https://doi.org/10.1016/B978–0–444–63459–7.00003–8

Esani, M. (2010). Moving from face-to-face to online teaching. *American Society for Clinical Laboratory Science*, *23*(3), 187–190. https://doi.org/10.29074/ascls.23.3.187

Espinoza, B. D., & Neal, M. (2018). Incorporating contextual knowledge in faculty professional development for online teaching. *Journal on Centers for Teaching and Learning*, *10*. 24–44. https://cetl.kennesaw.edu/journals/journal–centers–teaching–and–learning

Etikan, I., Musa, S. A., & Alkassim, R. S. (2016). Comparison of convenience sampling and purposive sampling. *American Journal of Theoretical and Applied Statistics*, *5*(1), 1–4. https://doi.org/10.11648/j.ajtas.20160501.11

Faul, F., Erdfelder, E., Buchner, A., & Lang, A. G. (2009). Statistical power analyses using G* Power 3.1: Tests for correlation and regression analyses. *Behavior research methods*, *41*(4), 1149–1160. https://doi.org/10.3758/brm.41.4.1149

Field, A. (2018). *Discovering statistics using IBM SPSS Statistics*. Sage.

Fink, A. (2003). *How to sample in surveys* (2nd ed.). SAGE Publications, Inc. https://www.doi.org/10.4135/9781412984478

Fraenkel, J., Wallen, N., & Hyun, H. (2018). *How to design and evaluate research in education* (10th ed.). McGraw–Hill Education.

Fricker, R. D. (2008). Sampling methods for web and e-mail surveys. In *The SAGE handbook of online research methods*, 195–216. SAGE Publications, Ltd, https://doi.org/10.4135/9780857020055.n11

Friday Institute for Educational Innovation. (2012a). *Teacher Efficacy and Attitudes Toward STEM Survey–Elementary Teachers* [Measurement instrument].

https://www.fi.ncsu.edu/resources/teacher–beliefs–and–attitudes–toward–stem–T-STEM–survey–tips–for–using–your–data/

Friday Institute for Educational Innovation. (2012b). *Teacher Efficacy and Attitudes Toward STEM Survey– Engineering Teachers.* [Measurement instrument]. https://www.fi.ncsu.edu/resources/teacher–beliefs–and–attitudes–toward–stem–T-STEM–survey–tips–for–using–your–data/

Friday Institute for Educational Innovation. (2012c). *Teacher Efficacy and Attitudes Toward STEM Survey– Mathematics Teachers.* [Measurement instrument]. https://www.fi.ncsu.edu/resources/teacher–beliefs–and–attitudes–toward–stem–T-STEM–survey–tips–for–using–your–data/

Friday Institute for Educational Innovation. (2012d). *Teacher Efficacy and Attitudes Toward STEM Survey– Science Teachers.* [Measurement instrument]. https://www.fi.ncsu.edu/resources/teacher–beliefs–and–attitudes–toward–stem–T-STEM–survey–tips–for–using–your–data/

Friday Institute for Educational Innovation. (2012e). *Teacher Efficacy and Attitudes Toward STEM Survey– Technology Teachers.* [Measurement instrument]. https://www.fi.ncsu.edu/resources/teacher–beliefs–and–attitudes–toward–stem–T-STEM–survey–tips–for–using–your–data/

Friday Institute for Educational Innovation. (2012f). *Teacher Efficacy and Beliefs toward STEM Survey: Development and Psychometric Properties.* [Measurement instrument]. https://www.fi.ncsu.edu/resources/teacher–beliefs–and–attitudes–toward–stem–T-STEM–survey–tips–for–using–your–data/

Gallagher, M. W. (2012). Self–efficacy. In V. S. Ramachandran (Ed.), *Encyclopedia of human behavior* (2nd ed., Vol. 4, pp. 71-81). Academic Press. https://doi.org/10.1016/B978–0–12–375000–6.00312–8

Gallavan, N. (2017). Introduction. In Bowles, D. A., & Pearman, C. J. (Eds.), *Self-efficacy in action: Tales from the classroom for teaching, learning, and professional development* (pp. xiii-xxi). Rowman & Littlefield Publishing Group.

Gardner, K., Glassmeyer, D., & Worthy, R. (2019). Impacts of STEM professional development on teachers' knowledge, self–efficacy, and practice. *Frontiers in Education, 4,* Article 26. https://doi.org/10.3389/feduc.2019.00026

Garson, G. D. (2012). *Testing statistical assumptions*. Statistical Associates Publishing.

Gloria, A. M., & Uttal, L. (2020). Conceptual considerations in moving from face–to–face to online teaching. *International Journal on E-Learning*, *19*(2), 139–159. https://www.aace.org/pubs/ijel/

Goddard, R. D., Hoy, W. K., & Hoy, A. W. (2000). Collective teacher efficacy: Its meaning, measure, and impact on student achievement. *American Educational Research Journal*, *37*(2), 479–507. https://doi.org/10.3102/00028312037002479

Gonzalez, K., & Maxwell, G. M. (2018). Mathematics teachers' efficacy, experience, certification and their impact on student achievement. *Journal of Instructional Pedagogies*, *21*. 1–11. https://www.aabri.com/jip.html

Greenleaf, R. K. (1973). *The servant as leader*. Center for Applied Studies.

Gross, B., Opalka, A., & Gundapaneni, P. (2020). *Getting back to school: An update on plans from across the country*. Center on Reinventing Public Education. https://crpe.org/our-publications/

Gurley, L. E. (2018). Educators' preparation to teach, perceived teaching presence, and perceived teaching presence behaviors in blended and online learning environments. *Online Learning, 22*(2), 197–220. https://doi.org/10.24059/olj.v22i2.1255

Harper, B. (2018). Technology and teacher–student interactions: A review of empirical research. *Journal of Research on Technology in Education*, *50*(3), 214–225. https://doi.org/10.1080/15391523.2018.1450690

Harrell, S., & Bynum, Y. (2018). Factors affecting technology integration in the classroom. *Alabama Journal of Educational Leadership, 5*, 12–18. https://www.icpel.org/state–affiliate–journals.html

Horovitz, S., & Weisberg, J. (2014). The impact of job insecurity on work performance: The hindrance and challenge process. In J. S. Gomes & J. P. Coelho (Eds.), *Values in shock: The role of contrasting management, economic, and religious paradigms in the workplace*. 140–149.

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

International Association for K–12 Online Learning (iNACOL). (2011a). *iNACOL: National standards for quality online teaching version 2*. North American Council for Online Learning. http://www.inacol.org/wp–content/uploads/2015/02/national–standards–for–quality–online–courses–v2.pdf

International Association for K–12 Online Learning (iNACOL). (2011b). *iNACOL: National standards for quality online courses version 2*. North American Council for Online Learning. http://www.inacol.org/wp–content/uploads/2015/02/national–standards–for–quality–online–courses–v2.pdf

Israel, G. D. (1992). *Determining sample size*. *Rep. No. IFAS Extension, PEOD6*. 1–5. Agricultural Education and Communication Department, University of Florida.

Johnson, R. B., & Christensen, L. (2019). *Educational research: Quantitative, qualitative, and mixed approaches*. SAGE Publications.

Jones, J., & Hidiroglou, M. (2013). Capturing, coding, and cleaning survey data. In *Designing and Conducting Business Surveys* (1st ed., pp. 459–504). John Wiley & Sons. https://doi.org/10.1002/9781118447895.ch11

Kaden, U. (2020). COVID-19 school closure–related changes to the professional life of a K–12 teacher. *Education Sciences*, *10*(6), 165 –178. https://doi.org/10.3390/educsci10060165

Kasalak, G., & Dağyar, M. (2020). The relationship between teacher self-efficacy and teacher job satisfaction: A meta-analysis of the teaching and learning international survey (TALIS). *Educational Sciences: Theory and Practice*, *20*(3), 16–33. https://doi.org/10.12738/jestp.2020.3.002

Kefalis, C., & Drigas, A. (2019). Web-based and online applications in STEM education. *iJEP*, *9*(4), 76–85. https://doi.org/10.3991/ijep.v9i4.10691

Keller, H. (2021, May 27). Virtual lab simulations don't teach science. *eLearningInside News.* https://news.elearninginside.com/virtual–lab–simulations–dont–teach–science/

Kelly, D., & Denson, C. (2017). STEM teacher efficacy in flipped classrooms. *Journal of STEM Education*, *18*(4), 43–50. https://www.jstem.org/jstem/index.php/JSTEM

Kennedy, J. (2015). Using TPCK as a scaffold to self–assess the novice online teaching experience. *Distance Education*, *36*(1), 148–154. http://dx.doi.org/10.1080/01587919.2015.1019964

Kennedy, T. J., & Odell, M. R. L. (2014). Engaging students in STEM education. *Science Education International*, *25*(3), 246–258. http://www.icaseonline.net/journal/index.php/sei

Keselman, H. J., Huberty, C. J., Lix, L. M., Olejnik, S., Cribbie, R. A., Donahue, B., Kowalchuk, R. K., Lowman, L. L., Petoskey, M. D., Keselman, J. C., & Levin, J. R. (1998). Statistical practices of educational researchers: An analysis of their ANOVA, MANOVA, and ANCOVA analyses. *Review of Educational Research*, *68*(3), 350–386. https://doi.org/10.3102/00346543068003350

Kim, K. R., & Seo, E. H. (2018). The relationship between teacher efficacy and students' academic achievement: A meta-analysis. *Social Behavior and Personality: An International Journal*, *46*(4), 529–540. https://doi.org/10.2224/sbp.6554

Kiray, S. A. (2016). Development of a TPACK self-efficacy scale for pre-service science teachers. *International Journal of Research in Education and Science*, *2*(2), 527–541. https://doi.org/10.21890/ijres.64750

Klassen, R. M., & Chiu, M. M. (2010). Effects on teachers' self-efficacy and job satisfaction: Teacher gender, years of experience, and job stress. *Journal of Educational Psychology*, *102*(3), 741–756. https://doi.org/10.1037/a0019237

Koehler, M., & Mishra, P. (2009). What is technological pedagogical content knowledge (TPACK)? *Contemporary Issues in Technology and Teacher Education*, *9*(1), 60–70. https://www.learntechlib.org/primary/p/29544/

Koenig, R. (2020, May 28). Pandemic may (finally) push online education into teacher prep programs. *EdSurge News*. https://www.edsurge.com/news/2020–05–28–pandemic–may–finally–push–online–education–into–teacher–prep–programs

Koonce, M., Pijanowski, J. C., Bengtson, E., & Lasater, K. (2019). Principal Engagement in the Professional Development Process. *NASSP Bulletin*, *103*(3), 229–252. https://doi.org/10.1177/0192636519871614

Kreitner, R., & Kinicki, A. (2009). *Organizational Behavior* (9th ed.). McGraw–Hill/Irwin.

Laerd Statistics. (2018). *Two-way ANOVA in SPSS Statistics*. Laerd Statistics. https://statistics.laerd.com/spss-tutorials/two-way-anova-using-spss-statistics.php

LaFollette, G. (2018). Learn about your customers with SurveyMonkey. *Journal of Accountancy*, *226*(6), 1–2. https://www.journalofaccountancy.com/

Larkin, I., Lokey–Vega, A., & Brantley–Dias, L. (2018). Retaining K–12 online teachers: A predictive model for K–12 online teacher turnover. *Journal of Online Learning Research*, *4*(1), 53–85. https://www.aace.org/pubs/jolr/

Larson, J. S., & Archambault, L. (2019). The extent of K–12 online teacher development: A disconnect between preparation and practice. In *Handbook of Research on Emerging Practices and Methods for K–12 Online and Blended Learning* (pp. 57–77). IGI Global. https://doi.org/10.4018/978–1–7998–8047–9.ch045

Lee, H. S., Mojica, G. F., & Lovett, J. N. (2020). Examining how online professional development impacts teachers' beliefs about teaching statistics. *Online Learning*, *24*(1), 5–27. https://doi.org/10.24059/olj.v24i1.1992

Lee, M.–H., Hsu, C.–Y., & Chang, C.–Y. (2019). Identifying Taiwanese Teachers' Perceived Self-efficacy for Science, Technology, Engineering, and Mathematics (STEM) Knowledge. *Asia–Pacific Education Researcher (Springer Science & Business Media B.V.)*, *28*(1), 15–23. https://doi.org/10.1007/s40299–018–0401–6

Lewis, D. I. (2014). *The pedagogical benefits and pitfalls of virtual tools for teaching and learning laboratory practices in the biological sciences.* The Higher Education Academy: STEM. https://www.heacademy.ac.uk/sites/default/files/resources/the_pedagogical_benefits_and_pitfalls_of_virtual_tools_for_teaching_and_learning_laboratory_practices_in_the_biological_sciences.pdf

Lin, C.–H., & Zheng, B. (2015). Teaching practices and teacher perceptions in online world language courses. *Journal of Online Learning Research*, *1*(3), 275–304. https://www.aace.org/pubs/jolr/

Lippke, S. (2017). Self-efficacy theory. In V. Zeigler–Hill & T. K. Shackelford (Eds.) *Encyclopedia of personality and individual differences* (pp. 4722–4727). Springer. https://doi.org/10.1007/978–3–319–28099–8_1167–1

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: Research*, *16*. 1–14. https://doi.org/10.28945/3626

Lynch, S., & Gaston, T. (2020). Quality matters impact on student outcomes in an online program. *Journal of Educators Online*, *17*(2), 1–8. https://www.thejeo.com/

Marsh, R. M., Carr–Chellman, A. A., & Sockman, B. R. (2009). Selecting silicon: Why parents choose cybercharter schools. *TechTrends*, *53*(4), 32–36. https://doi.org/10.1007/s11528–009–0303–9

Martin, L. E., & Mulvihill, T. M. (2019). Voices in education: Teacher self-efficacy in education. *The Teacher Educator*, *54*(3), 195–205. https://doi.org/10.1080/08878730.2019.1615030

McKim, A. J., & Velez, J. J. (2016). An evaluation of the self-efficacy theory in agricultural education. *Journal of Agricultural Education, 57*(1), 73–90. https://doi.org/10.5032/jae.2016.01073

Mertler, C. A. (2021). *Introduction to educational research* (3rd ed.). SAGE Publications.

Meyer, A., Rose, D. H., & Gordon, D. T. (2014). *Universal design for learning: Theory and practice*. CAST Professional Publishing.

Molnar, A., Miron, G., Elgeberi, N., Barbour, M. K., Huerta, L., Shafer, S. R., & Rice, J. K. (2019). *Virtual schools in the United States 2019*. National Education Policy Center. http://nepc.colorado.edu/publication/virtual–schools–annual–2019

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

Muijs, D. (2011). *Doing quantitative research in education with SPSS* (2nd ed.). SAGE Publications, Ltd. https://www.doi.org/10.4135/9781849203241

National Standards for Quality Online Learning. (2019a). *National Standards for Quality Online Courses* (3rd ed.). https://www.nsqol.org/wp–content/uploads/2019/02/National–Standards–for–Quality–Online–Teaching.pdf

National Standards for Quality Online Learning. (2019b). *National Standards for Quality Online Teaching* (3rd ed.). https://www.nsqol.org/wp–content/uploads/2019/09/National–Standards–for–Quality–Online–Courses–Catalog3–2019.09.01.pdf

Norman, G. (2010). Likert scales, levels of measurement and the “laws” of statistics. *Advances in Health Sciences Education, 15*(5), 625–632. https://doi.org/10.1007/s10459–010–9222-y

Ofem, B., Polizzi, S. J., Rushton, G. T., Beeth, M., Couch, B., Mohr–Schroeder, M., Roehrig, G., & Sheppard, K. (2019, August). Gender effects on perceived professional mastery: Evidence from STEM teachers. In *Academy of Management Annual Meeting Proceedings*, *2019*(1), 522–527. https://doi.org/10.5465/AMBPP.2019.93

Oliveira, A., Feyzi Behnagh, R., Ni, L., Mohsinah, A. A., Burgess, K. J., & Guo, L. (2019). Emerging technologies as pedagogical tools for teaching and learning science: A literature review. *Human Behavior and Emerging Technologies*, *1*(2), 149–160. https://doi.org/10.1002/hbe2.141

Oster–Levinz, A., & Klieger, A. (2010). Online tasks as a tool to promote teachers' expertise within the Technological Pedagogical Content Knowledge (TPACK). *Procedia–Social and Behavioral Sciences*, *2*(2), 354–358. https://doi.org/10.1016/j.sbspro.2010.03.024

Owan, V. J., & Bassey, B. A. (2019). Data management practices in educational research. *In PN Ololube & GU Nwiyi (Eds.), Encyclopedia of institutional leadership, policy, and management: A handbook of research in honour of Professor Ozo-Mekuri Ndimele*, (pp. 1251–1265). Pearl Publishers, Ltd. https://philpapers.org/rec/OWADMP

Oymak, O., & Ogan–Bekiroglu, F. (2021). Comparison of Students’ Learning and Attitudes in Physical versus Virtual Manipulatives using Inquiry-Based Instruction. *IAFOR Journal of Education*, *9*(4), 23–42. https://doi.org/10.22492/ije.9.4.02

Pallant, J. (2020). *SPSS survival manual: A step by step guide to data analysis using IBM SPSS*. Routledge.

Pearson, E. S. (1931). The analysis of variance in cases of non–normal variation. *Biometrika*, *23,* 114–133. https://doi.org/10.1093/biomet/23.1-2.114

Pfitzner–Eden, F. (2016). Why do I feel more confident? Bandura's sources predict preservice teachers' latent changes in teacher self–efficacy. *Frontiers in Psychology*, *7*, 1–16. https://doi.org/10.3389/fpsyg.2016.01486

Phuong, N. V. (2017). Peer observation of teaching: A formative lens to enhance academics' confidence and self-efficacy in teaching. *International Journal of Management and Applied Science*, *2394*(7926), 115–119. http://ijmas.iraj.in/

Polatcan, M. (2020). The effect of servant leadership on teacher alienation: The mediating role of supportive school culture. *International Online Journal of Educational Sciences*, *12*(3), 57–67. https://doi.org/10.15345/iojes.2020.03.005

Poulou, M. (2007). Personal teaching efficacy and its sources: Student teachers' perceptions. *Educational Psychology*, *27*(2), 191–218. https://doi.org/10.1080/19415257.2019.1643393

Price, J. H., & Murnan, J. (2004). Research limitations and the necessity of reporting them. *American Journal of Health Education*, *35*(2), 66–67. https://doi.org/10.1080/19325037.2004.10603611

Quality Matters. (2020). *K–12 specific review standards from the QM K–12 rubric, fifth edition for K–12 reviews*. https://www.qualitymatters.org/qa–resources/rubric–standards/k–12–secondary–rubric

Queirós, A., Faria, D., & Almeida, F. (2017). Strengths and limitations of qualitative and quantitative research methods. *European Journal of Education Studies*. *3*(9), 369–387. https://oapub.org/edu/index.php/ejes/index

Renbarger, R., & Davis, B. K. (2019). Mentors, self–efficacy, or professional development: Which mediate job satisfaction for new teachers? A regression examination. *Journal of Teacher Education and Educators*, *8*(1), 21–34. http://jtee.org/

Rennar–Potacco, D., & Orellana, A. (2018). Academically supporting STEM students from a distance through videoconferencing: Lessons learned. *American Journal of Distance Education*, *32*(2), 131–149. https://doi.org/10.1080/08923647.2018.1446121

Rhode, J., Richter, S., & Miller, T. (2017). Designing personalized online teaching professional development through self–assessment. *TechTrends, 61*(5), 444–451. https://doi.org/10.1007/s11528–017–0211–3

Rice, M. F. (2018). Supporting literacy with accessibility: Virtual school course designers' planning for students with disabilities. *Online Learning, 22*(4), 161–179. https://doi.org/10.24059/olj.v22i4.1508

Salkind, N. J. (Ed.). (2010). *Encyclopedia of research design* (Vol 1.). SAGE Publications. https://doi.org/10.4135/9781412961288

Salkind, N. J. (2012). *Exploring research,* (8th ed.), Pearson Higher Ed. https://doi.org/10.1111/j.1470–6431.2011.01075_2.x

Schunk, D. H., & DiBenedetto, M. K. (2020). Motivation and social cognitive theory. *Contemporary Educational Psychology*, *60*, Article 101832. https://doi.org/10.1016/j.cedpsych.2019.101832

Schwartz, S. H. (2012). An overview of the Schwartz theory of basic values. *Online Readings in Psychology and Culture*, *2*(1), 2307–0919. https://doi.org/10.9707/2307–0919.1116

Schwarzer, R., & Hallum, S. (2008). Perceived teacher self-efficacy as a predictor of job stress and burnout: Mediation analyses. *Applied Psychology*, *57*, 152–171. https://doi.org/10.1111/j.1464–0597.2008.00359.x

Seltman, H. J. (2018). *Experimental design and analysis.* [Unpublished manuscript]. Faculty of College of Humanities and Social Sciences, Carnegie Mellon University. http://www.stat.cmu.edu/~hseltman/309/Book/Book.pdf

Shahzad, K., & Naureen, S. (2017). Impact of teacher self-efficacy on secondary school students' academic achievement. *Journal of Education and Educational Development*, *4*(1), 48–72. https://doi.org/10.22555/joeed.v4i1.1050

Simpson, S. H. (2015). Creating a data analysis plan: What to consider when choosing statistics for a study. *The Canadian Journal of Hospital Pharmacy*, *68*(4), 311–317. https://doi.org/10.4212/cjhp.v68i4.1471

Siwatu, K. O., Chesnut, S. R., Alejandro, A. Y., & Young, H. A. (2016). Examining pre–service teachers' culturally responsive teaching self-efficacy doubts. *The Teacher Educator*, *51*(4), 277–296. https://doi.org/10.1080/08878730.2016.1192709

Skaalvik, E. M., & Skaalvik, S. (2014). Teacher self-efficacy and perceived autonomy: Relations with teacher engagement, job satisfaction, and emotional exhaustion. *Psychological Reports*, *114*(1), 68–77. https://doi.org/10.2466/14.02.pr0.114k14w0

Skaalvik, E. M., & Skaalvik, S. (2016). Teacher stress and teacher self-efficacy as predictors of engagement, emotional exhaustion, and motivation to leave the teaching profession. *Creative Education*, *7*, 1785–1799. https://doi.org/10.4236/ce.2016.713182

Spears, L. C. (2010). Character and servant leadership: Ten characteristics of effective, caring leaders. *The Journal of Virtues & Leadership, 1*(1), 25–30. https://doi.org/10.1057/9780230299184_2

Sue, V. M., & Ritter, L. A. (2012). *Conducting online surveys* (2nd ed.). SAGE Publications. https://www.doi.org/10.4135/9781506335186

Sutcher, L., Darling–Hammond, L., & Carver–Thomas, D. (2019). Understanding teacher shortages: An analysis of teacher supply and demand in the United States. *Education Policy Analysis Archives*, *27*(35), 1–40. https://doi.org/10.14507/epaa.27.3696

Swan, B. G., Wolf, K. J., & Cano, J. (2011). Changes in teacher self-efficacy from the student teaching experience through the third year of teaching. *Journal of Agricultural Education*, *52*(2), 128–139. https://doi.org/10.5032/jae.2011.02128

Taber, K. S. (2018). The use of Cronbach's alpha when developing and reporting research instruments in science education. *Research in Science Education*, *48*(6), 1273–1296. https://doi.org/10.1007/s11165–016–9602–2

Taherdoost, H. (2016). Sampling methods in research methodology; how to choose a sampling technique for research. *International Journal of Academic Research in Management 5*(2), 18–27. https://doi.org/10.2139/ssrn.3205035

Tanak, A. (2018). Designing TPACK–based course for preparing student teachers to teach science with technological pedagogical content knowledge. *Kasetsart Journal of Social Sciences*. 53–59. https://doi.org/10.1016/j.kjss.2018.07.012

Theofanidis, D., & Fountouki, A. (2018). Limitations and delimitations in the research process. *Perioperative Nursing*, *7*(3), 155–163. https://www.journal.acorn.org.au/jpn/

Thibaut, L., Ceuppens, S., De Loof, H., De Meester, J., Goovaerts, L., Struyf, A., Boeve–de Pauw, J., Dehaene, W., Deprez, J., De Cock, M., Hellinckx, L., Knipprath, H., Langie, G., Struyven, K., Van de Velde, D., Van Petegem, P., & Depaepe, F. (2018). Integrated STEM education: A systematic review of instructional practices in secondary education. *European Journal of STEM Education*, *3*(1), 2. 1–12. https://doi.org/10.20897/ejsteme/85525

Tibola, L. R., Herpich, F., da Silva, P. F., & Tarouco, L. M. R. (2019). Experience in teaching science in virtual environment. *International Journal of Innovation Education and Research*, *7*(4), 23–43. https://doi.org/10.31686/ijier.Vol7.Iss4.1375

Tømte, C., Enochsson, A. B., Buskqvist, U., & Kårstein, A. (2015). Educating online student teachers to master professional digital competence: The TPACK–framework goes online. *Computers & Education*, *84*, 26–35. https://doi.org/10.1016/j.compedu.2015.01.005

Tschannen–Moran, M., & McMaster, P. (2009). Sources of self–efficacy: Four professional development formats and their relationship to self-efficacy and implementation of a new teaching strategy. *The Elementary School Journal*, *110*(2), 228–245. https://doi.org/10.1086/605771

Tuckman, B. W., & Harper, B. E. (2012). *Conducting educational research*. Rowman & Littlefield Publishers.

Türkoğlu, M. E., Cansoy, R., & Parlar, H. (2017). Examining relationship between teachers' self-efficacy and job satisfaction. *Universal Journal of Educational Research 5*(5), 765–772. https://doi.org/10.13189/ujer.2017.050509

University of Colorado. (2021). *PhET Interactive Simulations*. PhET. https://phet.colorado.edu/

US Department of Education. (2020). Institute of Education Sciences, National Center for Education Statistics. *Table showing Number and enrollment of public elementary and secondary schools, by school level, type, and charter, magnet, and virtual status: Selected years, 1990–91 through 2018–19.* National Center for Education Statistics. https://nces.ed.gov/programs/digest/d20/tables/dt20_216.20.asp

Varela, C., Ruiz, J., Andrés, A., Roy, R., Fusté, A., & Saldaña, C. (2016). Advantages and disadvantages of using the website SurveyMonkey in a real study: Psychopathological profile in people with normal–weight, overweight and obesity in a community sample. *E–methodology*, *2016*(3), 77–89. https://e–methodology.eu/index.php/e–methodology/article/view/10.15503.emet2016.77.89

Verma, J. P., & Abdel–Salam, A. S. G. (2019). *Testing statistical assumptions in research*. John Wiley & Sons. https://doi.org/10.1002/9781119528388

von Fischer, P., & de Jong, D. (2017). The relationship between teacher perception of principal servant leadership behavior and teacher job satisfaction. *Servant Leadership: Theory & Practice*, *4*(2), 52–84. https://csuepress.columbusstate.edu/sltp/

Wang, K., Rathburn, A., & Musu, L. (2019). *School choice in the United States: 2019.* (NCES 2019–106). https://nces.ed.gov/pubs2019/2019106.pdf

Willard, C. A. (2020). *Statistical methods: An introduction to basic statistical concepts and analysis*. Routledge. https://doi.org/10.4324/9780429261039

Wright, B., & Akgunduz, D. (2018). The relationship between technological pedagogical content knowledge (TPACK) self-efficacy belief levels and the usage of Web 2.0 applications of pre-service science teachers. *World Journal on Educational Technology: Current Issues*, *10*(1), 52–69. https://doi.org/10.18844/wjet.v10i1.3332

Wright, D. S., Balgopal, M. M., Sample McMeeking, L. B., & Weinberg, A. E. (2019). Developing resilient K–12 STEM teachers. *Advances in Developing Human Resources*, *21*(1), 16–34. https://doi.org/10.1177%2F1523422318814483

Wu, H., Qiu, S., Dooley, L. M., & Ma, C. (2020). The relationship between challenge and hindrance stressors and emotional exhaustion: The moderating role of perceived servant leadership. *International Journal of Environmental Research and Public Health*, *17*(1), 282–297. https://doi.org/10.3390/ijerph17010282

Wynants, S., & Dennis, J. (2018). Professional development in an online context: Opportunities and challenges from the voices of college faculty. *Journal of Educators Online*, *15*(1), 1–13. https://doi.org/10.9743/jeo2018.15.1.2

Xie, K., Nelson, M. J., Cheng, S. L., & Jiang, Z. (2021). Examining changes in teachers' perceptions of external and internal barriers in their integration of educational digital resources in K–12 classrooms. *Journal of Research on Technology in Education*, 1–26. https://doi.org/10.1080/15391523.2021.1951404

Yang, H. (2020). The effects of professional development experience on teacher self–efficacy: Analysis of an international dataset using Bayesian multilevel models. *Professional Development in Education*, *46*(5), 797–811. https://doi.org/10.1080/19415257.2019.1643393

Yoo, J. H. (2016). The effect of professional development on teacher efficacy and teachers' self–analysis of their efficacy change. *Journal of Teacher Education for Sustainability*, *18*(1), 84–94. https://doi.org/10.1515/jtes–2016–0007

Zheng, X., Yin, H., & Li, Z. (2019). Exploring the relationships among instructional leadership, professional learning communities and teacher self-efficacy in China. *Educational*

Management Administration & Leadership, *47*(6), 843–859. https://doi.org/10.1177/1741143218764176

Appendix A

Informed Consent

AMERICAN COLLEGE of EDUCATION

Prospective Research Participant: Read this consent form carefully and ask as many questions as you like before deciding whether you want to participate in this research study. You are free to ask questions at any time before, during, or after you participate in this research.

Project Information	
Title: A Causal-comparative Study of Teacher Self-efficacy in Virtual Charter Schools	
Researcher: Lori Alverson	**Researcher's Dissertation Chair:** Dr. Jamie Ball
Organization: American College of Education	**Organization and Position:** American College of Education; Core Faculty
Email: lori.alverson0036@my.ace.edu	**Email:** Jamie.ball@ace.edu
Telephone: (909) 272–5615	

Dear Participant,

I am Lori Alverson, a Doctoral Candidate student at the American College of Education. I am researching under the guidance and supervision of my Chair, Dr. Jamie Ball. I will give you some information about the project and invite you to be part of this research. Before you decide, you can talk to anyone you feel comfortable with about the research. This consent form may contain words you do not understand; you may reach out to me before starting the survey.

Purpose of the Research

The purpose of this study is to increase the amount of information in the literature on how teacher efficacy impacts subject matter teaching beliefs, student outcomes, subject matter instruction, and other STEM-related topics. You are being asked to participate in a research study that will increase this knowledge in the literature. This quantitative study will determine if a statistically significant difference exists between elementary, science, technology, engineering, math subject matter, and virtual teaching experience on teacher efficacy and STEM attitudes composite scores.

Research Design and Procedures

The study will use a quantitative methodology and causal-comparative research design. The research will be comprised of 92 certified teachers from virtual charter schools in the United States. Sampling will be done through purposive and snowball methods. The study will involve taking a 10–minute survey online via SurveyMonkey.

Participant selection

You are invited to participate in this research because of your teaching experience in elementary, science, technology, engineering, or math in a virtual charter school in the United States. Your expert opinion can contribute much to teacher efficacy and STEM in this setting. Participant selection criteria will be from teachers in elementary, science, technology, engineering, and math teacher in K–12 virtual charter schools in the United States.

Voluntary Participation

Your participation in this research is entirely voluntary. It is your choice whether to participate. If you choose not to participate, there will be no punitive repercussions, and you do not have to participate. If you select to participate in this study, you may change your mind later and stop participating even if you agreed earlier.

Procedures

We are inviting you to participate in this research study. If you agree, you will be asked to take an online survey. The questions asked will range from demographics to direct inquiries about teacher efficacy and STEM attitudes.

Duration

The survey portion of the research study will require approximately 10 minutes to complete.

Risks

The researcher will ask you to share personal and confidential information, and you may feel uncomfortable talking about some of the topics. You do not have to answer any question or participate in the survey if you do not wish to. There is no probability of harm (physical, psychological, social, legal, or economic) occurring due to participation in this research study.

Benefits

While there will be no direct financial benefit to you, your participation will likely help us learn more about teacher efficacy and science, technology, engineering, and math professional development needs in the virtual charter school setting. This study's potential benefits will aid the professional development needs of teachers working in a fully remote, virtual charter school setting.

Confidentiality

Your identity will not be revealed at any time during the study. The survey will be anonymous to protect your privacy. The data collected from the survey will be compiled and used in a research study. The data collected will be kept in a locked file cabinet or encrypted computer file.

Sharing the Results

At the end of the research study, the results will be available for each participant. It is anticipated to publish the results for other interested people to learn from the research.

Right to Refuse or Withdraw

Participation is voluntary. You may end your participation in the research study at any time without any repercussions.

Questions About the Study

If you have any questions, you may ask them now or later. If you wish to ask questions, please contact Lori Alverson at lori.alverson0036@my.ace.edu. The Institutional Review Board of the American College of Education has reviewed and approved this research plan. This Institutional Review Board is a committee whose role is to ensure research participants are protected from harm. If you wish to ask questions of the committee, please email IRB@ace.edu.

Certificate of Consent

I have read the information about this study, or it has been read to me. I acknowledge why I have been asked to be a participant in the research study. I have been provided the opportunity to ask questions about the study, and any questions asked to have been answered to my satisfaction. I certify I am at least 18 years of age. I voluntarily consent to be a participant in this study. I confirm that I have not been coerced into giving consent, and my consent is given freely and voluntarily.

Do you agree to the above terms? By clicking Yes, you consent that you are willing to answer the questions in this survey.

Do you consent with your personal data being processed as described above? You must click Yes in order to take the survey.

Appendix B

Social Media Recruitment Sites and Recruiting Techniques

The recruitment will be passive and comply with the website policies and Terms of Use. There will be no direct interaction with potential participants. The survey results will be anonymous and voluntary, and the participant may withdraw at any time. Recruitment will be through social media group sites related to teaching (see Appendices B). In addition, a Facebook and LinkedIn advertisement will be utilized to recruit participants (see Appendices F and G).

Social Media Group Sites for Recruitment

[redacted]

Appendix C

Social Media Group Outreach Template

Dear Moderator/Owner of **Social Media Site**,

I hope this email finds you well. I am writing to inquire if you would consider posting my doctoral research study to your social media group.

The purpose of the research study will be to determine if a statistically significant difference exists between science, technology, engineering, and math (STEM) subject teaching and virtual teaching experience on teacher efficacy and attitudes towards STEM.

When the researcher has been approved for her research project from the American College of Education Institutional Review Board/ACE IRB, I agree to provide access for the approved research survey. If we have any concerns or need additional information, we will contact the American College of Education at (317) 829–9400 or IRB@ace.edu.

If you would email or direct message me back with the formal approval. An example template is attached for your usage.

Thank you again for considering this dissertation research opportunity.

AMERICAN COLLEGE of EDUCATION

Lori Alverson

Doctoral Candidate at American College of Education

Appendix D

Social Media Group Approval

Letter

[redacted]

Please be cautious
This email originated from outside of ACE organization

Social Media Group Approval

[redacted]

Subject: Site Approval Letter

Dear American College of Education IRB:

This letter acknowledges that I have received and reviewed a request by *Lori Alverson* to conduct a research project entitled "*A Causal-Comparative Study of Teacher Self-Efficacy in Virtual Schools*" [redacted] and I approve of this research to be conducted on our social media group.

When the researcher receives approval for his research project from the American College of Education's Institutional Review Board/ACE IRB, I agree to provide access for the approved research survey. The research will send the survey link anIf we have any concerns or need additional information, we will contact the American College of Education at (317) 829-9400 or IRB@ace.edu.

Sincerely,

[redacted]

Sent from my iPhone
CONFIDENTIAL EMAIL: This e-mail is intended solely for the addressee. The information contained herein is confidential. Any dissemination, distribution or copying of this e-mail, other than by its intended recipient, is strictly prohibited. If you have received this e-mail in error, please notify me immediately and delete this message.

[redacted]

Social Media Group Approval Template

[redacted]

Subject: Site Approval Letter

Dear American College of Education IRB:

This letter acknowledges that I have received and reviewed a request by *Lori Alverson* to conduct a research project entitled "*A Causal-Comparative Study of Teacher Self-Efficacy in Virtual Schools*" [redacted] and I approve of this research to be conducted on our social media group.

When the researcher receives approval for his research project from the American College of Education's Institutional Review Board/ACE IRB, I agree to provide access for the approved research survey. The researcher will send the survey link after approval is granted from the IRB. If we have any concerns or need additional information; we will contact the American College of Education at (317) 829-9400 or IRB@ace.edu.

Sincerely,

[redacted]

Approval for STEM group

DM [redacted]

To: Lori Alverson

Approval-Template_STEM-Fac...
19 KB

Please be cautious
This email originated from outside of ACE organization

Dear Lori,

Please find attached the signed template for your request.

I wish you good luck, and please, if possible, you are welcome to share some of your findings in our group.

best
[redacted]
STEM group owner
CONFIDENTIAL EMAIL: This e-mail is intended solely for the addressee. The information contained herein is confidential. Any dissemination, distribution or copying of this e-mail, other than by its intended recipient, is strictly prohibited. If you have received this e-mail in error, please notify me immediately and delete this message.

Reply | Forward

[redacted]

Appendix E

Social Media Groups Participant Recruitment

Would you please give me your expert opinion through a short, anonymous online survey? I am earning my doctorate in educational leadership with a focus on the online setting. The survey is a study of teacher self-efficacy in virtual charter schools.

Participants are those who:

1) work as a teacher in a virtual charter school located in the United States, and

2) teach any grade K–12, and

3) teach one of the following areas
   science,
   technology,
   engineering,
   math, or
   elementary students.

The **purpose** of this quantitative study will be to determine if a statistically significant difference exists between science, technology, engineering, and math (STEM) subject teaching and virtual teaching experience on teacher efficacy and attitudes towards STEM, across grades K–12.

The links to the informed consent and surveys are below

https://www.surveymonkey.com/r/QPVCVL2

It would also be helpful if you could forward the survey request to other teachers and co-workers who work in virtual charter schools and ask them to take the survey.

Thank you again for considering this dissertation research opportunity.

AMERICAN COLLEGE of EDUCATION

Lori Alverson

Doctoral Candidate at American College of Education

Appendix F

Facebook Advertisement and Terms of Service

Facebook Terms of Service

https://www.facebook.com/terms.php

Appendix G

LinkedIn Advertisement and Terms of Service

LinkedIn Terms of Service

https://legal.linkedin.com/linkedin–pages–terms

Appendix H

Snowball Sampling Recruitment

Teacher Efficacy and Attitudes Toward STEM in the Online Setting

Thank you for participating in this research study.

If you can please share the link to the informed consent and survey If you have a colleague or peer that meets the 3 requirements for participation:
https://www.surveymonkey.com/r/QPVCVL2
1) works as a teacher in a virtual charter school located in the United States, and
2) teaches any grade K-12, and
3) teaches one of the following areas
science,
technology,
engineering,
math, or
elementary students

Appendix I

Inclusion Criteria

The survey through SurveyMonkey will contain inclusion and exclusion criteria. The following qualifications will be given after the informed consent but before the survey questions.

Qualification

* Are you a full-time virtual teacher working in virtual charter school located in the United States?

- ◯ Yes, I am a full-time virtual teacher working in a virtual charter school located in the United States
- ◯ No

* How Many Years of Virtual Teaching Experience Do You Have?

- ◯ 0-2 years
- ◯ Between 2-5 years
- ◯ 5 or more years

* Do you teach K-12th grade students?

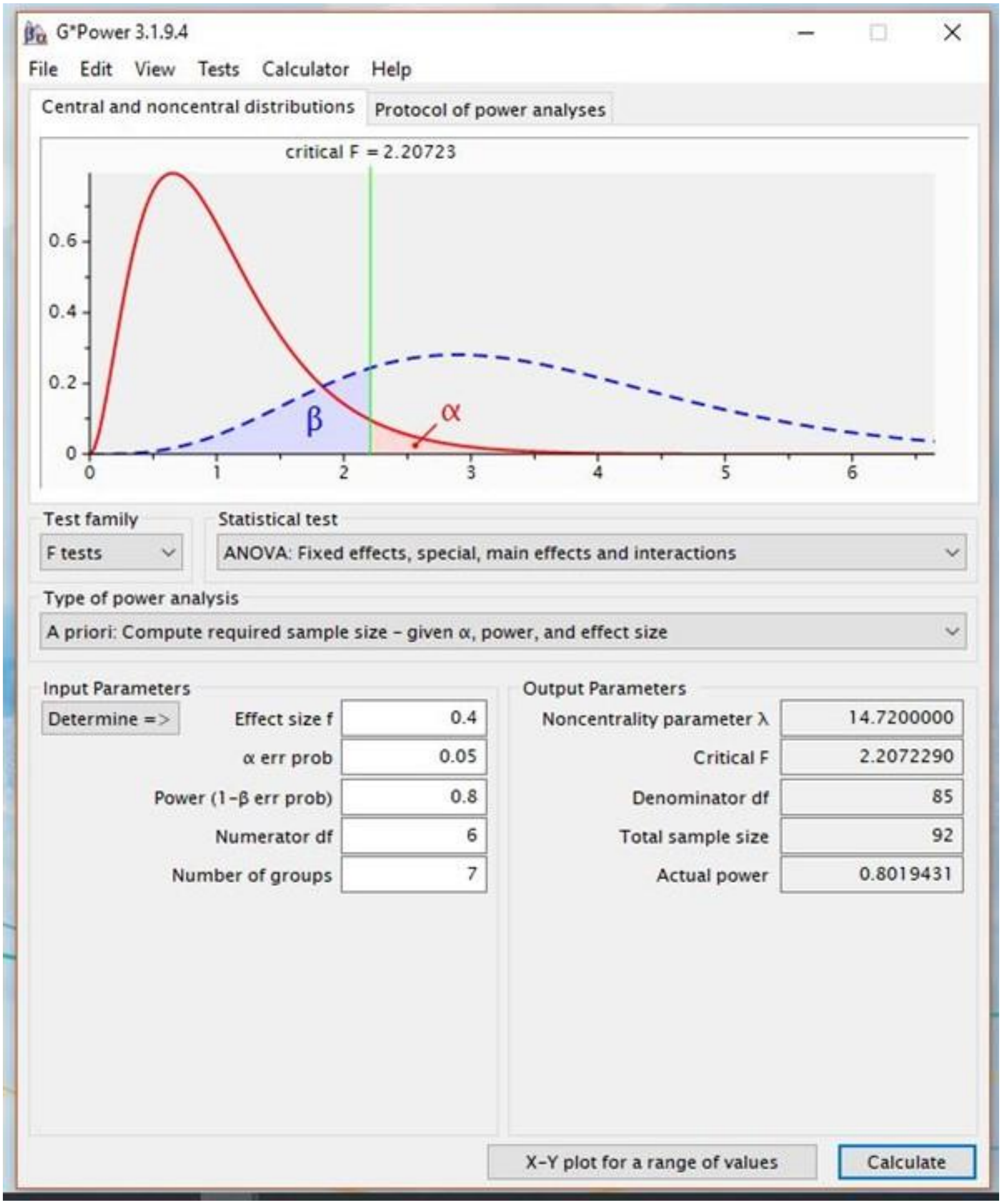
- ◯ Yes, I teach K-12th grade students
- ◯ No

* Which grade and subject area do you predominantly teach?

- ◯ Elementary K-5th or 6th grade students in the multiple subject teaching setting
- ◯ Science to 6-12th grade students
- ◯ Technology to 6-12th grade students
- ◯ Engineering to 6-12th grade students
- ◯ Math to 6-12th grade students
- ◯ None of the above

Appendix J

Sample Size Calculator with G*Power



Appendix K

Science Teacher Efficacy and Attitudes Toward STEM (T-STEM) Surveys

Science Teaching Efficacy and Beliefs

Directions: Please respond to these questions regarding your feelings about ***your own*** teaching.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1. I am continually improving my science teaching practice.	○	○	○	○	○
2. I know the steps necessary to teach science effectively.	○	○	○	○	○
3. I am confident that I can explain to students why science experiments work.	○	○	○	○	○
4. I am confident that I can teach science effectively.	○	○	○	○	○
5. I wonder if I have the necessary skills to teach science.	○	○	○	○	○
6. I understand science concepts well enough to be effective in teaching science.	○	○	○	○	○
7. Given a choice, I would invite a colleague to evaluate my science teaching.	○	○	○	○	○
8. I am confident that I can answer students' science questions.	○	○	○	○	○
9. When a student has difficulty understanding a science concept, I am confident that I know how to help the student understand it better.	○	○	○	○	○
10. When teaching science, I am confident enough to welcome student questions.	○	○	○	○	○
11. I know what to do to increase student interest in science.	○	○	○	○	○

Science Teaching Outcome Expectancy

Directions: The following questions ask about your feelings about teaching ***in general***. Please respond accordingly.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1. When a student does better than usual in science, it is often because the teacher exerted a little extra effort.	○	○	○	○	○
2. The inadequacy of a student's science background can be overcome by good teaching.	○	○	○	○	○
3. When a student's learning in science is greater than expected, it is most often due to their teacher having found a more effective teaching approach.	○	○	○	○	○
4. The teacher is generally responsible for students' learning in science.	○	○	○	○	○
5. If students' learning in science is less than expected, it is most likely due to ineffective science teaching.	○	○	○	○	○
6. Students' learning in science is directly realted to their teacher's effectiveness in science teaching.	○	○	○	○	○
7. When a low achieving child progresses more than expected in science, it is usually due to extra attention given by the teacher.	○	○	○	○	○
8. If parents comment that their child is showing more interest in science at school, it is probably due to the performance of the child's teacher.	○	○	○	○	○
9. Minimal student learning in science can generally be attributed to their teachers.	○	○	○	○	○

Student Technology Use

Directions: Please answer the following questions about how often students use technology in settings where you instruct students. If the question is not applicable to your situation, please select "Not Applicable."

During science instructional meetings (e.g. class periods, after school activities, days of summer camp, etc.), how often do your students…

	Never	Occasionall y	About half the time	Usually	Every time	Not Applicabl e
1. Use a variety of technologies, e.g. productivity, data visualization, research, and communication tools.	○	○	○	○	○	○
2. Use technology to communicate and collaborate with others, beyond the classroom.	○	○	○	○	○	○
3. Use technology to access online resources and information as a part of activities.	○	○	○	○	○	○
4. Use the same kinds of tools that professional researchers use, e.g. simulations, databases, satellite imagery.	○	○	○	○	○	○
5. Work on technology-enhanced projects that approach real-world applications of technology.	○	○	○	○	○	○
6. Use technology to help solve problems.	○	○	○	○	○	○
7. Use technology to support higher-order thinking, e.g. analysis, synthesis and evaluation of ideas and information.	○	○	○	○	○	○
8. Use technology to create new ideas and representations of information.	○	○	○	○	○	○

Science Instruction

Directions: Please answer the following questions about how often students engage in the following tasks during your instructional time.

During science instructional meetings (e.g. class periods, after school activities, days of summer camp, etc.), how often do your students…

	Never	Occasionally	About half the time	Usually	Every time
1. Develop problem-solving skills through investigations (e.g. scientific, design or theoretical investigations).	○	○	○	○	○
2. Work in small groups.	○	○	○	○	○
3. Make predictions that can be tested.	○	○	○	○	○
4. Make careful observations or measurements.	○	○	○	○	○
5. Use tools to gather data (e.g. calculators, computers, computer programs, scales, rulers, compasses, etc.).	○	○	○	○	○
6. Recognize patterns in data.	○	○	○	○	○
7. Create reasonable explanations of results of an experiment or investigation.	○	○	○	○	○
8. Choose the most appropriate methods to express results (e.g.drawings, models, charts, graphs, technical language, etc.).	○	○	○	○	○
9. Complete activities with a real-world context.	○	○	○	○	○
10. Engage in content-driven dialogue.	○	○	○	○	○
11. Reason abstractly.	○	○	○	○	○
12. Reason quantitatively.	○	○	○	○	○
13. Critique the reasoning of others.	○	○	○	○	○
14. Learn about careers related to the instructional content.	○	○	○	○	○

21st Century Learning Attitudes

Directions: Please respond to the following questions regarding your feelings about learning ***in general***.

"I think it is important that students have learning opportunities to…"

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1. Lead others to accomplish a goal.	○	○	○	○	○
2. Encourage others to do their best.	○	○	○	○	○
3. Produce high quality work.	○	○	○	○	○
4. Respect the differences of their peers.	○	○	○	○	○
5. Help their peers.	○	○	○	○	○
6. Include others' perspectives when making decisions.	○	○	○	○	○
7. Make changes when things do not go as planned.	○	○	○	○	○
8. Set their own learning goals.	○	○	○	○	○
9. Manage their time wisely when working on their own.	○	○	○	○	○
10. Choose which assignment out of many needs to be done first.	○	○	○	○	○
11. Work well with students from different backgrounds.	○	○	○	○	○

Teacher Leadership Attitudes

Directions: Please respond to the following questions regarding your feelings about teacher leadership ***in general***.

"I think it is important that teachers …"

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1. Take responsibility for all students' learning.	○	○	○	○	○
2. Communicate vision to students.	○	○	○	○	○
3. Use a variety of assessment data throughout the year to evaluate progress.	○	○	○	○	○
4. Use a variety of data to organize, plan and set goals.	○	○	○	○	○
5. Establish a safe and orderly environment.	○	○	○	○	○
6. Empower students.	○	○	○	○	○

STEM Career Awareness

Directions: Please respond to the following questions based upon how much you disagree or agree with the statements.

"I know …"

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1. About current STEM careers.	○	○	○	○	○
2. Where to go to learn more about STEM careers.	○	○	○	○	○
3. Where to find resources for teaching students about STEM careers.	○	○	○	○	○
4. Where to direct students or parents to find information about STEM careers.	○	○	○	○	○

Appendix L

Permission Letter to Use T-STEM Instrument

MISO

FRIDAY INSTITUTE FOR EDUCATIONAL INNOVATION

Golden LEAF FOUNDATION

Teacher Efficacy and Attitudes Toward STEM (T-STEM) Survey

Science Teacher

Last Updated October 2012

Appropriate Use
The Teacher Efficacy and Attitudes Toward STEM (T-STEM) Survey is intended to measure changes in teachers' confidence and self-efficacy in STEM subject content and teaching, use of technology in the classroom, 21st century learning skills, leadership attitudes, and STEM career awareness. The survey is available to help program coordinators make decisions about possible improvements to their program.

The Friday Institute grants you permission to use these instruments for educational, noncommercial purposes only. You may use an instrument as is, or modify it to suit your needs, but in either case you must credit its original source. By using this instrument you agree to allow the Friday Institute to use the data collected for additional validity and reliability analysis. The Friday Institute will take appropriate measures to maintain the confidentiality of all data.

Recommended citation for this survey:
Friday Institute for Educational Innovation (2012). *Teacher Efficacy and Attitudes Toward STEM Survey-Science Teachers*, Raleigh, NC: Author.

The development of this survey was partially supported by the National Science Foundation under Grant No. 1038154 and by The Golden LEAF Foundation.

The framework for part of this survey was developed from the following sources: Riggs, I. M., & Enochs, L. G. (1990). Toward the development of an elementary teachers science teaching efficacy belief instrument. *Science Education, 74*(6), 625-637. doi: 10.1002/sce.3730740605

Teacher Efficacy and Attitudes Toward STEM (T-STEM) Survey

Technology Teacher

Last Updated October 2012

Appropriate Use
The Teacher Efficacy and Attitudes Toward STEM (T-STEM) Survey is intended to measure changes in teachers' confidence and self-efficacy in STEM subject content and teaching, use of technology in the classroom, 21st century learning skills, leadership attitudes, and STEM career awareness. The survey is available to help program coordinators make decisions about possible improvements to their program.

The Friday Institute grants you permission to use these instruments for educational, noncommercial purposes only. You may use an instrument as is, or modify it to suit your needs, but in either case you must credit its original source. By using this instrument you agree to allow the Friday Institute to use the data collected for additional validity and reliability analysis. The Friday Institute will take appropriate measures to maintain the confidentiality of all data.

Recommended citation for this survey:
Friday Institute for Educational Innovation (2012). *Teacher Efficacy and Attitudes Toward STEM Survey-Technology Teachers*, Raleigh, NC: Author.

The development of this survey was partially supported by the National Science Foundation under Grant No. 1038154 and by The Golden LEAF Foundation.

The framework for part of this survey was developed from the following sources: Riggs, I. M., & Enochs, L. G. (1990). Toward the development of an elementary teachers science teaching efficacy belief instrument. *Science Education, 74*(6), 625-637. doi: 10.1002/sce.3730740605

Teacher Efficacy and Attitudes Toward STEM (T-STEM) Survey

Engineering Teacher

Last Updated October 2012

Appropriate Use
The Teacher Efficacy and Attitudes Toward STEM (T-STEM) Survey is intended to measure changes in teachers' confidence and self-efficacy in STEM subject content and teaching, use of technology in the classroom, 21st century learning skills, leadership attitudes, and STEM career awareness. The survey is available to help program coordinators make decisions about possible improvements to their program.

The Friday Institute grants you permission to use these instruments for educational, noncommercial purposes only. You may use an instrument as is, or modify it to suit your needs, but in either case you must credit its original source. By using this instrument you agree to allow the Friday Institute to use the data collected for additional validity and reliability analysis. The Friday Institute will take appropriate measures to maintain the confidentiality of all data.

Recommended citation for this survey:
Friday Institute for Educational Innovation (2012). *Teacher Efficacy and Attitudes Toward STEM Survey-Engineering Teachers*, Raleigh, NC: Author.

The development of this survey was partially supported by the National Science Foundation under Grant No. 1038154 and by The Golden LEAF Foundation.

The framework for part of this survey was developed from the following sources: Riggs, I. M., & Enochs, L. G. (1990). Toward the development of an elementary teachers science teaching efficacy belief instrument. *Science Education, 74*(6), 625-637. doi: 10.1002/sce.3730740605

Teacher Efficacy and Attitudes Toward STEM (T-STEM) Survey

Mathematics Teacher

Last Updated October 2012

Appropriate Use
The Teacher Efficacy and Attitudes Toward STEM (T-STEM) Survey is intended to measure changes in teachers' confidence and self-efficacy in STEM subject content and teaching, use of technology in the classroom, 21st century learning skills, leadership attitudes, and STEM career awareness. The survey is available to help program coordinators make decisions about possible improvements to their program.

The Friday Institute grants you permission to use these instruments for educational, noncommercial purposes only. You may use an instrument as is, or modify it to suit your needs, but in either case you must credit its original source. By using this instrument you agree to allow the Friday Institute to use the data collected for additional validity and reliability analysis. The Friday Institute will take appropriate measures to maintain the confidentiality of all data.

Recommended citation for this survey:
Friday Institute for Educational Innovation (2012). *Teacher Efficacy and Attitudes Toward STEM Survey-Mathematics Teachers*, Raleigh, NC: Author.

The development of this survey was partially supported by the National Science Foundation under Grant No. 1038154 and by The Golden LEAF Foundation.

The framework for part of this survey was developed from the following sources: Riggs, I. M., & Enochs, L. G. (1990). Toward the development of an elementary teachers science teaching efficacy belief instrument. *Science Education, 74*(6), 625-637. doi: 10.1002/sce.3730740605

MISO

FRIDAY INSTITUTE FOR EDUCATIONAL INNOVATION

Golden LEAF FOUNDATION

Teacher Efficacy and Attitudes Toward STEM (T-STEM) Survey

Elementary Teacher

Last Updated October 2012

Appropriate Use
The Teacher Efficacy and Attitudes Toward STEM (T-STEM) Survey is intended to measure changes in teachers' confidence and self-efficacy in STEM subject content and teaching, use of technology in the classroom, 21st century learning skills, leadership attitudes, and STEM career awareness. The survey is available to help program coordinators make decisions about possible improvements to their program.

Recommended citation for this survey:
Friday Institute for Educational Innovation (2012). *Teacher Efficacy and Attitudes Toward STEM Survey-Elementary Teachers*, Raleigh, NC: Author.

The development of this survey was partially supported by the National Science Foundation under Grant No. 1038154 and by The Golden LEAF Foundation.

The framework for part of this survey was developed from the following sources: Riggs, I. M., & Enochs, L. G. (1990). Toward the development of an elementary teachers science teaching efficacy belief instrument. *Science Education, 74*(6), 625-637. doi: 10.1002/sce.3730740605

Appendix M

IRB Research Approval Letter

AMERICAN COLLEGE of EDUCATION

June 21, 2021

To : Lori Alverson
Jamie Ball, Dissertation Committee Chair

From : Institutional Review Board
American College of Education

Re: IRB Approval

"A Causal-Comparative Study of Teacher Self-Efficacy in Virtual Schools"

The American College of Education IRB has reviewed your application, proposal, and any related materials. We have determined that your research provides sufficient protection of human subjects.

Your research is therefore approved to proceed. The expiration date for this IRB approval is one year from the date of review completion, June 21, 2022. If you would like to continue your research beyond this point, including data collection and/or analysis of private data, you must submit a renewal request to the IRB.

Our best to you as you continue your studies.

Sincerely,

Tiffany Hamlett
Chair, Institutional Review Board

IRBDRR_170606003
6_ApprovalLetter.pd