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by

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Dedication

This dissertation is dedicated to my beloved three children who have been my source of inspiration and motivation when I thought about giving up.

Acknowledgment

I would like to express my deepest gratitude to my dissertation chair and advisor, MaryBeth Walpole, Ph.D., for the time, effort, and guidance throughout this process. Her vast wisdom, expertise, experience, and encouragement inspired me to complete my dissertation. It would have been impossible to finish my study without her unwavering support.

Abstract

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Doctor of Education in Educational Leadership

The purpose of this study was to investigate whether the course, Scientific Inquiry, significantly increased the self-efficacy beliefs of its students. According to Bandura (1977), an increase in self-efficacy could increase the likelihood that teachers implement scientific inquiry in their classrooms. I explored self-efficacy in an effort to address the overarching problem, an overall inconsistency of inquiry teaching in classrooms. There are numerous benefits associated with the implementation of scientific inquiry in today's classrooms. A key question then to investigate was whether the experience students gain by taking the course Scientific Inquiry can alter student self-efficacy beliefs which could increase the likelihood that teachers implement scientific inquiry in their future classrooms. According to the data collected for this study, participating in this course increases student self-efficacy regarding scientific inquiry and may help change the course of our nation's scientific education for the better.

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Chapter 1

Introduction

Statement of the Problem

Science education is an important component of school instruction for all students (Amrita et al., 2014; National Academy of Sciences, 1997; National Research Council, 1996, 2012). Scientifically literate students develop and possess knowledge and skills required to make informed critical choices that arise daily (National Research Council, 1996, 2012). Moreover, scientifically literate students are equipped to effectively participate in important issues of science and technology that affect society (Beshears, 2012; National Academy of Sciences, 1997; National Research Council, 2006, 2012). They are also well prepared to compete successfully in the real world 21st century workforce (Barab & Dede, 2007; Bybee & Scotter, 2007; National Research Council, 1996, 2012).

Despite the importance of scientific education and scientific literacy for all students, student performance in US science classrooms continues to weaken (Marshall & Alston, 2014; National Center for Education Statistics, 2012, 2019). The 2015 National Assessment of Educational Progress (NAEP) assessment, a project of the federal Education Department, rated 24% of fourth-graders, 32% of eighth-graders and 40% of 12th-graders as below basic in scientific literacy (Desilver, 2017). The follow-up ratings in 2019 show an even further decline in fourth-grader's performance and no increase in the performance of eighth-graders or 12th-graders (Sparks, 2021). Additionally, US students continue to rank behind students in many other industrialized nations in science assessments. US students ranked 24th out of 71 countries in science on the 2015 Programme for International Student Assessment (Desilver, 2017). The findings make it clear that US students are struggling with science (Sparks, 2021).

Current science education teaching methods are ineffective and subsequently, may be failing our society (Hatch, 2018; National Science and Technology Council, 2013). Existing science education teaching methods are not properly preparing enough students to pursue science majors in college (ACT, 2016). Current science education teaching methods are also failing to produce a scientifically literate workforce (National Research Council, 1996, 2012; National Science and Technology Council, 2013). The quality of science education is directly associated with the number of competent scientists, technologists, engineers, as well as science teachers (Amrita et al., 2014). In the US, only 13% of the US workforce are employed in these occupations (Funk & Parker, 2018). Of the other 87%, 40% report having been at least somewhat interested in a STEM job at some point in their lives (Funk & Parker, 2018). Thus, current science education teaching methods are not working.

One possible reason for the ineffective science teaching methods being used in today's classrooms is that the undergraduate education of preservice teachers is not preparing teachers to become effective science teachers (Singer, et al., 2006). In many US classrooms, science is not a priority (Banilower et al., 2013; Dorph et al., 2007; Howitt et al., 2011; Sparks, 2021) and teachers feel unprepared to teach science well (Banilower et al., 2013). A 2013 national survey by Banilower et al. found that while 86% of elementary teachers felt prepared to teach reading, only 44% felt prepared to teach science.

Students continue to enter science classroom environments where the focus is on trivializing science education down to the memorization of key terms, use of mind-numbing textbooks, and teaching to standardized tests. Students are subjected to these ineffective science education teaching methods rather than being challenged to collect data, solve problems, and offer explanations as scientists do (Bruce, 2009; Beshears, 2012). Marshall and Alston (2014) reported that 82% of high school life science standards were written for lower-order thinking such as remembering for understanding and Banilower (2013) reported that 65% of elementary classes substantially rely on textbooks to guide their units. This type of teaching neglects the most important aspects of science such as independent thinking, experimental design, and problem solving. It is also uninteresting, unmotivating, and irrelevant to students (National Academy of Sciences, 1997).

Changes in science education teaching methods are increasingly focused on teachers, how they are trained, and how they interact with students (Hitch, 2018). Scientific inquiry has been recommended by a variety of prominent reform groups as an alternative and effective science education teaching and learning method for teachers to implement (American Association for the Advancement of Science [AAAS], 1993; National Commission on Excellence in Education [NCEE], 1983; Next Generation Science Standards [NGSS], 2013; National Research Council, 1996, 2000, 2012; Wenning, 2005). Scientific inquiry is a science education teaching and learning method that challenges students to actively develop scientific skills and knowledge in a hands-on manner through asking questions and solving scientific problems (Llewellyn, 2013; National Academy of Sciences, 1997). This approach to teaching and learning shifts the focus from “learning about” a concept to “figuring it out” (Hatch, 2018). It allows students to use practices similar to the actual work of scientists such as planning their own experiments, recording data, and drawing conclusions (National Research Council, 1996, 2012).

In order to make sense of how the world works, students require firsthand laboratory experiences with the physical world where they are actively learning about scientific phenomena (National Academy of Sciences, 1997). Scientific inquiry was developed based on both research and experience that found students learn best when they engage in hands-on science activities (National Academy of Sciences, 1997; National Research Council, 1996, 2012). Scientific inquiry aims to raise the performance expectations for what students should know and be able to do and to refocus and redefine science education instruction to include higher-order thinking skills and knowledge (NRC, 2012).

Scientific inquiry as a model for teaching and learning has been shown to have numerous educational advantages and benefits (Anderson, 1997; Burkam et al., 1997; Carey, 1985; Feng & McComas, 2015; Freedman, 1997; Lott, 1983; Schmidt et al., 2002; Shymansky, 1984; Uno, 1990; Von Secker, 2002; Von Secker & Lissitz, 1999; Wells, 1995). Inquiry-based instruction has been linked to higher student achievement (Feng & McComas, 2015; Marshall & Alston, 2014; Anderson, 1997; Burkam et al., 1997; Carey, 1985; Freedman, 1997; Lott, 1983; Shymansky, 1984; Uno, 1990; Von Secker, 2002; Von Secker & Lissitz, 1999; Wells, 1995); increased people skills, scientific knowledge growth, and student motivation (Kleine et al., 2002; Llewellyn, 2013); narrowing of the achievement gap of minority students relative to White students (Geier et al., 2008;

Marshall & Alston, 2014; Wilson et al., 2009); increased reasoning and argumentation skills (Fusaro & Smith, 2018; Llewellyn, 2013; Wilson et al., 2009); and better student attitudes (Feng & McComas, 2015; Shymansky, 1984).

Traditional teaching methods currently being used by science teachers such as lecturing, however, have no relationship to student achievement (Van Klaveren, 2011). In fact, students involved in traditional lecturing classrooms are 1.5 times more likely to fail when compared to students engaged in classrooms where students are actively learning (Freeman et al., 2014). The implementation of scientific inquiry by teachers in all U.S. schools as a teaching and learning model is important in order for K-12 science education students to perform better in science (National Research Council, 2000, 2012; Sparks, 2021). In fact, we are not going to see an increase in the nation's reporting scores until we spend more time doing scientific inquiry (Sparks, 2021).

Despite the numerous advantages and benefits of scientific inquiry, its implementation in science classrooms remains inconsistent (Capps & Crawford, 2012; Cigdemoglu & Köseoğlu, 2019; Damnjanovic, 1999; DiBiase & McDonald, 2015; Drayton & Falk, 2000; Hurd et al., 1980; Llewellyn, 2005; Marshall & Alston, 2014; National Center for Education Statistics, 2019; Smolleck & Nordgren, 2014; Sparks, 2021; Tal & Argaman, 2005; Wenning, 2005; Windschitl, 2002). NAEP analysis found that 30% of 4th graders, 42% of 8th graders, and 50% of 12th graders only engage in scientific inquiry investigations once or twice a year and sometimes never (Sparks, 2021). Further, inquiry is not perceived by teachers as a favorable teaching method in today's science classrooms (DiBiase & McDonald, 2015). A major reason for the inconsistency of inquiry teaching in classrooms is the fact that many of today's science teachers have not been exposed to inquiry-based learning and thus lack experience with scientific inquiry (Costenson & Lawson, 1986; DiBiase & McDonald, 2015; Kleine et al., 2002; NRC, 2000; Tamir, 1983; Windschitl, 2002).

Teachers tend to model their teaching after previous instructors and experiences. In many cases, they teach the way they were taught (Johnson, 2006; Oleson & Hora, 2014; Singer et al., 2006). Oleson and Hora (2014) concluded that 79% of math and science instructors cited that previous class experiences directly influenced their current teaching practices. Thus, their lack of experience with scientific inquiry makes it difficult for many teachers to adopt and implement inquiry teaching and learning into their classrooms (Chichekian & Shore, 2016; Damnjanovic, 1999) because they do not believe that they are skilled enough to lead inquiry-based investigations with their students (DiBiase & McDonald, 2015; Hurd et al., 1980).

Beliefs such as these can drastically influence the decisions teachers make regarding their behavior in the classroom (Chichekian & Shore, 2016; DiBiase & McDonald, 2015; Fang, 1996; Fishman et al., 2003; Kagan, 1992; Khanshan & Yousefi, 2020; Thompson, 1992; Tschannen-Moran & Woolfolk-Hoy, 2001, 2007; Wallace & Kand, 2004; Woolfolk-Hoy & Spero, 2005; Zee & Kooman, 2016). These beliefs, specifically self-efficacy beliefs, have actually been shown to be the most reliable indicators of the decisions that teachers make throughout their careers (Pajares, 1992; Zee & Kooman, 2016). These beliefs and subsequent decisions were studied extensively by Albert Bandura (1977).

According to Albert Bandura (1997), "self-efficacy refers to beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (p. 3). Self-efficacy beliefs have been shown to be strong indicators of human behavior (Bandura, 1977; Ghaith & Yaghi, 1997; Gibson & Dembo, 1984; Guskey, 1988; Pajares, 1992; Singer et al., 2000; Windschitl, 2002), effective predictors of teacher behavior in science classrooms (Bandura, 1986; Chichekian & Shore, 2016; Riggs & Enochs, 1990; Wallace & Kand, 2004; Tschannen-Moran & Hoy, 2007; Woolfolk-Hoy & Spero, 2005; Zee & Kooman, 2016), and have been linked to teachers' willingness to implement new instructional techniques (Berman et al., 1977; Guskey, 1984; Rose & Medway, 1981; Wallace & Kand, 2004). In fact, low self-efficacy beliefs can lead teachers to avoid teaching particular subject matter such as scientific inquiry (Chichekian & Shore, 2016). Self-efficacy beliefs are, however, malleable (Henson, 2001; Luft & Roehrig, 2007; McKeown et. al., 2016; Tschannen-Moran & Hoy, 2007). Therefore, an effective way to understand the low priority of scientific inquiry teaching and increase its implementation in today's classrooms, as suggested by current reform documents, would be to examine how self-efficacy beliefs affect teacher behavior regarding the teaching of science as inquiry.

Many U.S. science teachers lack experience with scientific inquiry (Costenson & Lawson, 1986; DiBiase & McDonald, 2015; Kleine et al., 2002; NRC, 2000; Tamir, 1983; Windschitl, 2002). This lack of experience with inquiry instruction may help explain why science teachers in today's classrooms are not implementing scientific inquiry. A 2013 study by Capps and Crawford involving a group of 5^{th}-9^{th} grade teachers reported statistically significant changes in teacher knowledge and view of scientific inquiry after participating and being supported in a scientific inquiry-based experience. Participation in hands-on activities and modeling experiences with scientific inquiry has been shown to increase preservice teacher confidence and self-efficacy (Charalambous & Philippou, 2010; Chichekian & Shore, 2016; Liang & Richardson, 2009). Thus, teachers must be given an opportunity to experience inquiry-based teaching and learning themselves (Capps & Crawford, 2013; Chichekian & Shore, 2016; Enochs & Riggs, 1988, 1990; Kleine et al., 2002; Palmer, 2006; Smolleck et al., 2006) in order to alter their self-efficacy beliefs regarding the teaching of science as inquiry. Bandura's (1977) social learning theory supports the notion that teachers who complete a course that provides an opportunity to experience inquiry-based instruction are more likely to alter their self-efficacy beliefs and feel more comfortable implementing scientific inquiry in their own classrooms.

According to Bandura's social learning theory (1977), modeling and successful mastery experiences lead to an increase in self-efficacy. Thus, if preservice teachers have successful experiences with scientific inquiry, they may model more effective instruction with students in their own classrooms. In an effort to provide this necessary experience with scientific inquiry and potentially influence teacher self-efficacy beliefs, University A provides a course entitled Scientific Inquiry. The course Scientific Inquiry introduces students to the scientific habits of mind by physically and mentally engaging them in the study of everyday life phenomenon related to science. Students make observations, ask questions, collect and analyze data, as well as communicate and compare results. The branches of science that may be covered in the course include earth science, biology, physics, and chemistry. Ultimately, they are provided an opportunity to successfully experience scientific inquiry for themselves. However, the extent to which this course influences self-efficacy beliefs has not been tested empirically.

Purpose of the Study

This quantitative, pre-post-test study examined whether the course, Scientific Inquiry, significantly increased the self-efficacy beliefs of its students. According to Bandura (1977), an increase in self-efficacy could increase the likelihood that teachers implement scientific inquiry in their classrooms. As future science teachers, students are responsible for successfully leading the next generation of students in effective science lessons (Llewellyn, 2013). I explored self-efficacy in an effort to address the overarching problem, an overall inconsistency of inquiry teaching in classrooms. This is important and worthy of study because of the numerous benefits associated with the implementation of scientific inquiry in today's classrooms and the negative outcomes associated with its absence. A key question then to investigate was whether the experience students gain by taking the course Scientific Inquiry can alter student self-efficacy beliefs which could increase the likelihood that teachers implement scientific inquiry in their future classrooms.

When teachers receive support and direct experience with scientific inquiry, they are more likely to make it a priority in their science classrooms (DiBiase & McDonald, 2015; Chichekian & Shore, 2016; Kleine et al., 2002). An institution in the northeast United States, University A, offers a course called Scientific Inquiry to provide its students with a model teacher, materials, and guidance with scientific inquiry instruction.

The course aims to give students the support and experience they currently lack but is necessary for promoting inquiry-based instruction in their future classrooms.

The opportunity to experience scientific inquiry in the course could alter student self-efficacy beliefs regarding scientific inquiry (Chichekian & Shore, 2016). Providing this course is critical because self-efficacy beliefs in general have been shown to be much more malleable for preservice teachers than they have been for in-service teachers (Bandura 1997; Tschannen-Moran & Woolfolk-Hoy, 2002, 2007). Thus, this study examined whether the course significantly increases the self-efficacy beliefs of its students which, according to Bandura (1977), could increase the likelihood that teachers implement scientific inquiry in their future classrooms.

As such, the purpose of this dissertation was to examine the effects of the course, Scientific Inquiry, on the self-efficacy beliefs of students regarding teaching science as inquiry because higher self-efficacy levels may encourage its implementation in their future classrooms. Using a quantitative, pre-post-test design and the Teaching Science as Inquiry (TSI) Instrument, this study examined students' self-efficacy beliefs before taking a Scientific Inquiry course and at the end of the course to determine whether a significant difference exists between the mean scores for the pre-test and the mean scores of the post-test questions. This was done to determine if a difference exists in students self-efficacy beliefs regarding the teaching of science as inquiry after taking the course. Additionally, a series of Wilcoxon Signed Rank Tests was run to determine whether there were significant differences between the scores for the pre-test and the post-test by question.

A Spearman’s rank correlation coefficient with one tail was run to determine how the independent variables, Mean of the pre-test means, sex, preservice status, and class year, are related to the dependent variable, the post-test score. This was done to determine if the independent variables mediate students’ self-efficacy beliefs regarding the teaching of science as inquiry.

This study specifically examined sex because different sexes have different experiences and thus differences in their self-efficacy beliefs throughout their education (Rayburn, 2009; Simpkins et al., 2006; Wright & Holttum, 2010). Females believe their success in science courses to be lower than their male counterparts (Betz & Hackett, 1997; Britner & Pajares, 2001, 2006; Kupermintz, 2002; Lau & Roeser, 2002; Pajares, 1997; Rayburn, 2009; Zeldin et al., 2008). This is an important distinction since the National Center for Education Statistics reported in 2016 that 77% of public school teachers are female. Additionally, women remain vastly underrepresented in the science, technology, engineering, and math (STEM) workforce despite their ability to increase America's innovative capacity and global competitiveness (Rayburn, 2009; US Department of Commerce Executive Summary, 2011). The lack of women in these high-paying/high-skill fields leaves an untapped opportunity to expand STEM employment in the United States. (Beede et al., 2011). As such, an investigation into the role of sex on self-efficacy may also help explain the underrepresentation of women in science.

The study also examined the role of preservice status of participants on students’ self-efficacy beliefs regarding the teaching of science as inquiry. Additionally, the study examined the role of class year on students’ self-efficacy beliefs regarding the teaching of science as inquiry. Research investigating the connection between the implementation of scientific inquiry and other variables such as the number of years taught, the highest degree held by the teacher, and the prior educational and work experiences found no existing correlation (Chichekian & Shore, 2016). This study will add to the attempt to find a correlation.

Research Questions

1. What are the effects of the course Scientific Inquiry on students' self-efficacy beliefs?
2. To what extent does Mean of the pre-test means, sex, preservice status, and class year predict students' post-test self-efficacy score?

Significance

This proposed study was significant and worthy because the implementation of scientific inquiry in U.S. schools can benefit many students, and by extension, the U.S. scientific workforce. This study showed that the course Scientific Inquiry, offered at University A, influences students' self-efficacy beliefs regarding teaching scientific inquiry. Implementing scientific inquiry is imperative because of the numerous educational advantages to students that could have incredibly positive outcomes for U.S. science education (Anderson, 1997; Burkam et al., 1997; Carey, 1985; Freedman, 1997; Schmidt et al., 2002; Shymansky, 1984; Uno, 1990; Von Secker, 2002; Von Secker & Lissitz, 1999; Wells, 1995).

Key Terms

Science Education

The teaching and learning of science to school children, college students, or adults within the general public.

Scientific Inquiry

A multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations (National Research Council, 2000).

Self-Efficacy Beliefs

The beliefs in one’s capabilities to organize and execute the courses of action required to produce given attainments.

Dissertation Outline

This dissertation is organized into five chapters. In this, the first chapter, Introduction, I state the research problem and the purpose of the research. I introduce the research questions and define key terms. In Chapter 2, Review of Literature, I further explore and discuss the ideas presented in Chapter 1 citing relevant literature to support the ideas presented. In Chapter 3, Methods, I restate the research questions and then discuss the research design used to answer them. I describe the instrument that was used to collect data as well as the validity and reliability of the instrument. I also discuss the research setting and participants and the analytic approaches. In Chapter 4, Findings, I discuss what I found according to the data collected and present an overview of the results of the research. In Chapter 5, Discussion, I describe the significance of the results presented. I discuss the limitations of the research and implications for research, practice, and leadership. I also offer conclusions supported by the findings of the research and discuss the answer to the research problem.

Chapter 2

Review of Literature

Scientific Inquiry Teaching and Learning

Scientific inquiry, as a learning and teaching model, has been supported and promoted by many prominent figures and organizations in various ways since its conception (Burkam et al., 1997; Carey, 1985; Feng & McComas, 2015; Freedman, 1997; Lott, 1983; Schmidt et al., 2002; Shymansky, 1984; Uno, 1990; Von Secker, 2002; Von Secker & Lissitz, 1999). Socrates was said to have used a series of question and response techniques associated with scientific inquiry with his students to promote their understanding of ideas (Dow, 1999; Uno, 1990). In the early twentieth century, John Dewey supported the teaching of discovery learning and inquiry where students learn from direct experience and involvement with exploration and personal reflection of one's own solutions (Beshears, 2012; Llewellyn, 2013). Dewey's ideas paved the way for Piaget, Vygotsky, and Brunner who advocated for classrooms where students actively construct their own knowledge with teachers serving as facilitators (Beshears, 2012).

Scientific inquiry was also supported by Joseph J. Schwab in the 1960's (Llewellyn, 2013). Schwab aimed to create a revolution in American science education by encouraging the teaching and learning of scientific principles through a process of "scientific enquiry." Despite the spelling variation, Schwab championed the ideas of scientific inquiry where scientific knowledge is discovered by gathering and interpreting data (Schwab, 1962). Scientific inquiry is an important feature in reform documents that emphasize the use of inquiry-based instruction for all students (American Association for the Advancement of Science, 1993; National Commission on Excellence in Education [NCEE], 1983; National Research Council [NRC], 1996; National Research Council [NRC], 2000).

Scientific inquiry can, in fact, have various meanings and definitions. In a 1996 report highlighting the importance of scientific inquiry, the National Research Council (NRC) defined scientific inquiry as "the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work" (NRC, 1996, p. 23.) This definition provided by the National Review Council is based on the *National Science Education Standards,* which provide a complete vision of a classroom based on standards and scientific inquiry (Drayton & Falk, 2000).

The NRC recognizes that science is the process of gaining knowledge about the development of scientific principles, theories, and explanations regarding how the world works. They distinguish this from science as a means of simply accumulating facts about scientific principles (Drayton & Falk, 2001). Scientific inquiry compels students to use critical thinking skills to identify misconceptions and reconsider existing explanations of scientific phenomena. According to the NRC (1996), scientific inquiry engages students in activities such as making observations; asking questions; gathering and studying resources to determine and review what is already known; planning experiments; using appropriate tools and techniques to conduct experiments and gather data; analyzing and interpreting data; thinking critically and analytically about relationships between evidence and explanations; comparing experimental data to existing data; proposing answers, explanations, and predictions; and communicating experimental results.

Defining scientific inquiry in this manner differentiates scientific inquiry from inquiry in a general sense and from inquiry that scientists perform. It is explained through the process skills associated with scientific inquiry such as emphasizing questions, gathering evidence, and offering explanations on scientific concepts (NRC, 2000). Thus, this definition will be used for the purposes of this study.

The NRC (2000) definition of scientific inquiry as a learning and teaching model includes five essential features. Those features are:

- Learner engages in scientifically oriented questions
- Learner gives priority to evidence in responding to questions
- Learner formulates explanations from evidence
- Learner connects explanations to scientific knowledge
- Learner communicates and justifies explanations (2000, p. 29).

When used in the classroom, teachers have the option to include all five essential features or to leave one or more out. A lesson that includes all five essential features is referred to as full inquiry. If one or more is not utilized in a lesson, it is considered a partial inquiry (NRC, 2000).

Teachers also have the option to modify the amount of help they provide to students during the scientific inquiry lesson. The amount of help provided by the teacher determines the level of inquiry and thus the intellectual involvement required by the students. There are four levels: confirmation, structured, guided, and open. In a confirmation inquiry, students are given the most help upfront. They are provided with the question, procedure, and the solution. The students are instructed to confirm the predetermined results of the lab during their investigation. A structured inquiry will provide students with the question and the procedure, but the solution will be determined through collecting data on their own and forming conclusions (Lott, 2011).

A guided inquiry occurs when the teacher asks a question that students are challenged to answer through experimentation (Llewellyn, 2005). Students are required to plan the investigation, collect relevant data, and make conclusions based on the results of their investigation (Lott, 2011). This type of scientific inquiry lesson is more teacher-directed than an open inquiry (NRC, 2000). Guided inquiries are of more value to students who will require assistance with a topic and also tend to be less time consuming than an open inquiry (Matyas, 2000).

If the lesson is more student-directed, the lesson would be referred to as an open inquiry (NRC, 2000). An open inquiry occurs when the teacher allows students the opportunity to propose the question to investigate. Open inquiries allow students a chance to perform experiments from the beginning, where they identify a problem to investigate, to the end, where they determine a resolution on their own (Roth, 1995). Open inquiries may be more time consuming than other teaching methods. However, open inquiries provide the highest level of inquiry because students generate and investigate questions that they formulate themselves (Llewellyn, 2005).

Research on Scientific Inquiry Teaching and Learning

Despite the variations and different levels of the scientific inquiry lesson, students in all grades and in all science classes should be given the opportunity to use scientific inquiry and be encouraged to think and act in ways related to scientific inquiry (NRC, 2012). However, the manner in which the content of the scientific inquiry lesson is taught will most likely change based on the grade level of the class. The NRC divides the *National Science Education Standards* into three distinct groups based on grade levels, K-4, 5-8, and 9-12, each grade having its own specific standards. These grade specific standards allow teachers to determine what students should know and what process skills they should be able to perform (Llewellyn, 2001; 2013). Teachers from each grade level group will therefore have their own specific way to integrate scientific inquiry into their lessons.

The NRC (1996, 2000, 2012) also explains the importance of delivering lessons to students at appropriate levels based on their individual developmental abilities. For example, elementary students are at a beginner level, but they can start to develop the physical and intellectual skills associated with scientific inquiry. They can begin to design their own investigations in an attempt to see what happens. Students in grades 5-8 are able to expand on these skills by beginning to determine relationships between evidence they gather and explanations offered. They are able to comprehend how their background knowledge and theories help to guide the design of their investigations, observations, and interpretations of data and how to identify and modify misconceptions associated with their current ideas and background knowledge. Students in grades 9-12 are able to begin to develop more sophisticated abilities and understandings of scientific inquiry. They are better equipped to comprehend that their investigations are guided by specific scientific concepts and are performed to test those concepts. Thus, while inquiry-based instruction may be suitable for all grade levels, teachers must consider that the lessons will need to be modified according to the developmental capabilities of students in each grade (NRC, 1996, 2012).

In addition to scientific inquiry as an effective teaching and learning model for all grade levels, it is also effective for all content areas. In fact, research shows that effective scientific inquiry lessons have been developed in content areas such as science, history, drama, math, literature, and social studies (Beshears, 2012; Wells, 1995). For example, physics inquiry-based projects based on computer programs and labs for topics such as thermal equilibrium and centripetal force have been successfully run (Clark, 2008; Llewellyn, 2005). Similarly, environmental inquiry-based field studies on stream activity or biological concepts have been successful (Shepardson, 2008). Although, because Earth's materials vary, can be missing, or are difficult to obtain, it can sometimes be difficult to represent real-world conditions in a classroom. Thus, scientific inquiry has been described as difficult for many earth science topics. While at times difficult, they can still be conducted when inquiries are based on observations about a specific Earth event by using models to test current explanations (Pyle, 2008).

Scientific inquiry lessons have also led to greater mathematical understanding in math classrooms and have contributed to increased literacy development because they encourage constant reading, writing, listening, and speaking (Schmidt et al., 2002). The reading of literature has its own form of scientific inquiry in literature classes. Inquiries into historical events or periods using historical documents allow history teachers an opportunity to make use of scientific inquiry as a teaching model. Additionally, improvisation in drama classes can be treated as a form of inquiry. Thus, scientific inquiry as a teaching and learning model can be effectively utilized across all grade levels and in all major disciplines (Beshears, 2012; Wells, 1995).

Scientific inquiry teaching and learning has been shown to be effective in a variety of ways (McComas, 2005). It provides an opportunity to spark student curiosity about science. It also may help students become more open to take risks and take on responsibilities in their classrooms. It may help students become more objective and precise. Additionally, scientific inquiry will show students that science is a dynamic process of investigation as opposed to a collection of unchangeable facts (Uno, 1990; National Research Council, 1996, 2012).

Students presented with scientific inquiry-based lessons were more likely to participate in hands-on activities. They tend to revisit their work more frequently, to perform groupwork in pairs or small groups, to collect and discuss data, and to discuss strategies. Teachers who offer scientific inquiry-based lessons are less likely to give lectures on scientific principles, to perform demonstrations, and have students who take text or lecture-based notes (Drayton & Falk, 2000). Scientific inquiry-based lessons open doors for students to be more spontaneous and have more moments of insight. In addition, these lessons increase general motivation to participate in lessons as well as increase motivation for students who rarely have success with academics (Klein, 2002).

In 1983, Lott performed a seminal meta-analysis of 39 studies published from 1957 through 1980 and found that scientific inquiry teaching and learning led to significantly better performance when high levels of thought were considered when compared to lecturing students. The same study revealed that scientific inquiry teaching and learning led to essentially equal performance on low level cognitive outcomes when compared to lecturing students (Costenson & Lawson, 1986). Scientific inquiry based methods of instruction have also been shown to lead to better student attitudes (Feng &

McComas, 2015; Shymansky, 1984), higher student achievement (Feng & McComas, 2015; Marshall & Alston, 2014; Anderson, 1997; Burkam et al., 1997; Carey, 1985; Freedman, 1997; Lott, 1983; Shymansky, 1984; Uno, 1990; Von Secker, 2002; Von Secker & Lissitz, 1999; Wells, 1995); increased people skills and scientific knowledge growth (Kleine et al., 2002; Llewellyn, 2013); increased reasoning and argumentation skills (Llewellyn, 2013; Wilson et al., 2009); and to better performance regarding high levels of thought (Costenson & Lawson, 1986; Llewellyn, 2013). In general, the NRC (2012) claims that classrooms that use scientific inquiry as a teaching and learning model are the most effective for learning for understanding.

Reform Efforts on Scientific Inquiry Teaching and Learning

Reform efforts calling for the implementation of scientific inquiry have become plentiful and popular due to the overwhelming amount of positive research in favor of scientific inquiry-based instruction. The U.S. Department of Education's 1983 National Commission on Excellence in Education (NCEE) reported in *A Nation at Risk: The Imperative for Educational Reform* that American schools are failing and not competing as well as previous years as compared with other countries. This report included new models of teaching science and was one of the first to recommend that students utilize methods of scientific inquiry (NCEE, 1983).

Shortly thereafter, *Benchmarks for Science Literacy Project 2061*, was published by the American Association for the Advancement of Science (AAAS, 1993). *Benchmarks for Science Literacy Project 2061* offered recommendations regarding what all students should know and be able to do in science, mathematics, and technology by the end of grades 2, 5, 8, and 12. The report proposed that all students should design and carry out at least one major investigation before graduating from high school. This investigation should include a question, the design of the investigation, an estimation of the time and costs involved, calibration of the instruments, trial runs, report writing, and responses to criticism (AAAS, 1993). The report made clear the importance of inquiry-based lessons. *A Nation at Risk: The Imperative for Educational Reform* and *Benchmarks for Science Literacy Project 2061* both supported the inclusion of scientific inquiry in science classrooms.

Following their lead, the National Research Council (NRC) released the *National Science Education Standards* in 1996. This document has since been a driving force behind U.S. science education (NRC, 2000). The *National Science Education Standards* were founded in exemplary practice and research and designed as a guide toward becoming a scientifically literate nation. They describe a vision of a scientifically literate person and offer criteria for science educators to make that vision become reality (NRC, 1996). A major part of this vision was to highlight the importance of scientific inquiry teaching and learning in the nation's classrooms.

In 2000, Drayton and Falk discussed mandated changes to educational reform programs at the national and state levels to promote a deeper understanding of science concepts through use of scientific inquiry. They found that scientific inquiry is a component of state standards and frameworks in many districts nationwide. Thus, it is clear that current research and current reform efforts support the notion that the implementation of scientific inquiry in today's classrooms is an important element of science education and instruction and we cannot solely rely on traditional methods any longer.

Traditional Classroom vs. Inquiry-Based Classroom

Traditional classroom curriculum emphasizes mere knowledge of scientific facts, laws, theories, and applications. Laboratory investigations in traditional classroom curriculum are used to verify concepts already covered in the classroom. Under this type of learning atmosphere, students learn to view science as a collection of inalterable facts to memorize. Students learn to view explanations as reports of isolated events (Chiappetta, 2008; NRC, 2000; Shymansky, 1984). Schwab described this learning atmosphere as an "unmitigated rhetoric of conclusions in which the current and temporary constructions of scientific knowledge are conveyed as empirical, literal, and irrevocable truths" (Schwab, 1962, p. 24). This type of classroom was most often seen during the first half of the 20^{th} century when the view of scientific teaching and learning was to actually just teach students factual information (Chiappetta, 2008).

This type of traditional learning environment is still in place and specifically administered to students through use of teacher led demonstrations, lectures, and cookbook labs (Beshears, 2012; DiBiase & McDonald, 2015; Hurd et al., 1980; Llewellyn, 2013; NRC, 2000). Eagan et al. (2014) found that 51% of teachers continue to employ extensive use of lecturing. This is important to note because traditional methods have been shown to be less effective than scientific inquiry-based methods of instruction (Cetin, 2021; Costenson & Lawson, 1986; Feng & McComas, 2015; Shymansky, 1984).

One reason to explain the continued use of traditional laboratory methods is that they may often be effective for teachers in terms of time constraints and efficiency (Backus, 2005; Brandwein, 1962; DiBiase & McDonald, 2015; Llewellyn, 2013). For example, most high school chemistry laboratory investigations contain procedures with instructions regarding exactly how to perform the experiment, collect the necessary data, and analyze the findings. These step-by-step laboratory investigations, allowing students to successfully confirm an existing predetermined conclusion, only take about 40 or 50 minutes (Backus, 2005; Brandwein, 1962).

While efficient, these traditional laboratory methods do not employ higher levels of thinking. In fact, they often eliminate opportunities for higher levels of thinking, scientific inquiry, and independent discovery. The traditional laboratory methods of instruction fail to get students to discover and explore all of the limitations and alternate possibilities regarding what is already known or not known (Backus, 2005; Schwab, 1962). Traditional methods of investigations simply do not align with recommendations of constructivist teaching or with the way scientists actually investigate phenomena (McComas, 2005). These kinds of methods are not as effective for students in terms of student performance (Feng & McComas, 2015; Shymansky, 1984), attitudes, interest, learning, and intellectual development (Costenson & Lawson, 1986; Feng & McComas, 2015). These methods are not how students learn most effectively (Freeman et al., 2014; Van Klaveren, 2011; Wells, 1995).

Conversely, scientific inquiry lab investigations provide students with an opportunity investigate a new problem, brainstorm ideas about the problem, create a plan for an investigation, perform the investigation, critically analyze the findings, draw conclusions, and make any necessary adaptations to adjust the investigation (Backus, 2005). Scientific inquiry provides students with an opportunity to understand that science is more than just a collection of facts and explanations (Drayton & Falk, 2001; Medawar, 1984). Rather, it allows students the chance to see that scientific knowledge shifts as explanatory theories are produced to answer scientific questions based on the latest discoveries (Drayton & Falk, 2001).

Implementing scientific inquiry methods may require a new and elevated level of experience on the part of teachers. They will need to learn how to successfully engage students in scientific inquiry without interfering. Teachers would learn through experience how to provide guidance to assist students as needed. They still have a very active role ensuring that students are on track (Banchi & Bell, 2008).

Scientific inquiry methods also require a new level of practice on the part of students. They will need to learn new responsibilities and techniques that are necessary when traditional or cookbook laboratory methods are replaced by scientific inquiry learning. These new learning skills, such as planning their own experiments, recording data, and drawing conclusions, will be more developed the more students have opportunities to practice them (Banchi & Bell, 2008). It will require some work on part of the teachers and students. However, the result will certainly be worth the effort (McComas, 2005).

Resistance to Scientific Inquiry Teaching and Learning

Research suggests that scientific inquiry instruction is not a key feature in today's classrooms despite the mandates calling for its implementation and the abundant research demonstrating its effectiveness (Capps & Crawford, 2012; Cigdemoglu & Köseoğlu, 2019; Costenson & Lawson, 1986; Damnjanovic, 1999; DiBiase & McDonald, 2015; Drayton & Falk, 2000; Hurd et al., 1980; Llewellyn, 2005; Marshall & Alston, 2014; McComas, 2005; Tal & Argaman, 2005; Wenning, 2005; Windschitl, 2002). In fact, traditional teaching methods continue to be the more popular method of teaching science among teachers today (Costenson & Lawson, 1986; DiBiase & McDonald, 2015; Hofer & Lembens, 2019; Hurd et al., 1980; NRC, 2000; Raloff, 1988). Additionally, in a study involving 149 K-12 teachers, Capps, Shemwell, and Young (2016) found that teachers often claim to and believe they are using scientific inquiry methods but actually were not. Similarly, DiBiase and McDonald (2015) found that while 75% of teachers surveyed reported using inquiry in their classrooms, 65% did not feel they had sufficient background knowledge to actually be successful with inquiry. However, because traditional teaching methods are not as effective as scientific inquiry in terms of student attitudes, interest, learning, and intellectual development, teachers should consider other options (Costenson & Lawson, 1986; Feng & McComas, 2015).

There are a host of challenges that help explain the low priority of scientific inquiry-based instruction in today's classrooms. Costenson and Lawson (1986) described some of the challenges associated with scientific inquiry instruction. The authors found that developing good scientific inquiry lessons may often take too much time and energy and is therefore slow. They noted that student immaturity could be a problem. Lastly, they found that many teachers do not feel comfortable with the lack of total control regarding what is happening during the class time.

More recently, DiBiase and McDonald (2015) also found numerous challenges associated with scientific inquiry implementation. Of the 275 middle and high school science teachers they studied, 78% believe that students would have difficulty constructing meaning from scientific inquiry investigations. They found that 79% of teachers believe that inquiry takes up too much class time, 59% believe inquiry lessons take too much time to develop, and 61% believe that students would mismanage their own time if presented with lessons in an inquiry format. They noted that 86% of teachers expressed concerns regarding use of collaborative group work associated with scientific inquiry methods. Teachers also expressed concerns about scientific inquiry being able to adequately prepare students for standardized tests, which 81% of the teachers cited as an important end-of-year goal. Of the same teachers, 86% cited that students should participate in laboratory exercises where the outcomes are already known as opposed to developing and participating in the design process, 81% of teachers believe that teaching scientific facts is important, 72% agree that open-ended questions as an assessment tool was a concern, and 66% of teachers cited following the textbook as the best method of developing their curriculum.

These findings are in direct opposition of to what reform efforts are calling for (Beshears, 2012). Further, while 81% of teachers agreed that students should be able to design their own investigations, an alarming 68% were still reluctant to implement inquiry activities into their lessons. Teachers seem to lack an understanding of inquiry and how to conduct inquiry lessons in their classrooms (DiBiase & McDonald, 2015).

Another challenge to the implementation of scientific inquiry-based instruction is that teachers may believe that scientific inquiry will only benefit highly motivated and gifted students, which would limit its use only to students in advanced classes (Hurd et al., 1980). Additionally, many science teachers are only interested and comfortable doing traditional or cookbook labs because they know that the outcome of the investigation relates to a certain part of the science curriculum they already intended to cover (Llewellyn, 2001). Other challenges reported regarding scientific inquiry-based instruction include issues with safety, equipment requirements, management problems, and the school requirement to teach their mandated curriculum (Wallace & Kand, 2004). These challenges may offer some suggestions to explain the lack of scientific inquiry instruction in classrooms.

Another area worthy of exploration are the self-efficacy beliefs regarding the teaching of science as inquiry based on sex. Males and females have different experiences throughout their education (Rayburn, 2009; Simpkins et al., 2006). For example, females typically believe their success in science courses to be lower than their male counterparts (Betz & Hackett, 1997; Britner & Pajares, 2001, 2006; Kupermintz, 2002; Lau & Roeser, 2002; Pajares, 1997; Rayburn, 2009; Zeldin et al., 2008). Females continue to view themselves as less capable in science, are less confident that they will be successful in science and are less likely to major in science disciplines (Rayburn, 2009). This may lead to differences in their self-efficacy beliefs (Rayburn, 2009; Simpkins et al., 2006; Wright & Holttum, 2010). Because most public school teachers are female (National Center for Education Statistics, 2016), it is important to examine the role of sex on self-efficacy beliefs.

Self-Efficacy

One major explanation regarding why teachers may not readily accept and utilize scientific inquiry methods over traditional ones is that some teachers do not believe they possess the ability to teach scientific inquiry labs (Chichekian & Shore, 2016; DiBiase & McDonald, 2015; Hurd et al., 1980). Many teachers have had no experience with inquiry-based investigations (Costenson & Lawson, 1986; Kleine et al., 2002; Tamir, 1983; Windschitl, 2002). Because of their lack of experience with inquiry-based teaching and learning they find it difficult to utilize in their classrooms (Damnjanovic, 1999). Thus, these teachers may not believe they are competent enough to conduct inquiry-based investigations with their students (DiBiase & McDonald, 2015; Hurd et al., 1980). Specifically, DiBiase and McDonald found that 65% of teachers were not confident about their ability to teach using scientific inquiry methods.

These beliefs influence the decisions a teacher makes and how they behave in their classrooms (Chichekian & Shore, 2016; Fang, 1996; Kagan, 1992; Khanshan & Yousefi, 2020; Fishman et al., 2003; Thompson, 1992; Tschannen-Moran & Woolfolk-Hoy, 2007; Woolfolk-Hoy & Spero, 2005). In fact, beliefs such as these are the "best indicators of the decisions that individuals make throughout their lives" (Pajares, 1992, p. 307). An investigation of these beliefs could help to explain why teachers remain inconsistent regarding implementing inquiry-based instruction as a regular teaching model in their classrooms. Thus, in order to increase the implementation of scientific inquiry instruction in today's classrooms, it would be worthwhile to assess the self-efficacy beliefs of pre-service teachers regarding the teaching of science as inquiry.

Defining Self-Efficacy

Bandura defined self-efficacy as the "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (1997, p. 3). Bandura theorized that peoples' beliefs about the action-outcome relationship (a belief that X leads to Y) do not ultimately lead to behavior. He suggested that behavior stems from a person's self-efficacy (a belief that they can do X) (Ghaith & Yaghi, 1997; Tschannen-Moran & Hoy, 2007).

Bandura (1977) proposed that one's beliefs in their self-efficacy can cause different behaviors. Their beliefs can influence what behaviors one chooses, the amount of effort they put forth in a given situation, the amount of time they will put forth dealing with obstacles and failures associated with that situation, their resilience to adverse conditions associated with that situation, their thought patterns, the amount of stress they will experience in coping with the demands of that situation, and the level of accomplishments they feel as a result of their involvement with that situation (Bandura, 1977).

Bandura (1977) supported the notion that people are frightened and will avoid situations they do not believe they have the ability to handle. They will find it hard to motivate themselves, will lessen their efforts, or give up quickly when confronted with obstacles. They will have low aspirations and a weak sense of commitment regarding the goals of the situation. When stressed, they will focus on their own shortcomings and possible calamities, the difficulty of the task, and the consequences associated with failing as opposed to focusing on how best to execute activities. These thinking patterns will undermine their overall effort and analysis of the situation. They will recover their sense of efficacy following failure or setbacks and retain faith in their capabilities at a slower rate. They are more likely to experience stress and depression (Bandura, 1977).

Contrastingly, Bandura (1977) asserted people will favor situations they believe they can handle successfully. People who have strong beliefs in their abilities do not see difficult situations as threats but more as challenges to be mastered. They have high aspirations, set challenging goals, and have a strong sense of commitment regarding the goals of the situation. They will put forth a high level of effort in the task and increase those efforts when faced with failures or setbacks. When stressed, they will think strategically and focus on how best to execute activities to remain task focused. They will recover their sense of efficacy following failure or setbacks and retain faith in their capabilities at a higher rate. These thinking patterns cultivate captivating interest and involvement in the task. They are less likely to experience stress and depression.

Bandura's (1977) line of reasoning follows that behavior is influenced more by what one believes rather than on what is actually true. Thus, investigating the self-efficacy beliefs of pre-service teachers in regard to scientific inquiry teaching and learning could help predict whether or not they are likely to utilize it. It could also help predict how well they will persevere when faced with difficulties in their future classrooms.

Teacher Self-Efficacy

Julian Rotter (1966) proposed a different theory on teacher efficacy describing it as an internal-external locus of control. His locus of control, which was seen by some to be similar in nature to Bandura's (1977) perceived self-efficacy, focuses on the beliefs about the relationship between actions taken and outcomes produced. According to Rotter's ideas, a teacher may believe that a certain outcome can be caused by their actions but still have little confidence that they can actually accomplish those actions (Goddard et al., 2000). Thus, perceived self-efficacy, or beliefs about whether one can produce certain actions, is different than locus of control, or beliefs about whether actions affect outcomes. Further, research suggests that perceived self-efficacy and locus of control have a small or no empirical relationship to each other. While perceived self-efficacy is a strong predictor of human behavior, locus of control tends to be a weak predictor (Huangfu, 2012; Tschannen-Moran et al., 1998; Tschannen-Moran & Hoy, 2001). Thus, this study will focus on Bandura's ideas of self-efficacy as related to teacher behavior.

In addition to being good predictors of human behavior, teacher self-efficacy has been linked to student achievement (Allinder, 1995; Armor, et al., 1976; Ashton & Webb, 1986; Berman et. al., 2016; Bruce et al., 2010; Gibson & Dembo, 1984; McLaughlin et al., 1977; Tschannen-Moran & Hoy, 2001, 2007), attitudes, and motivation (Tschannen-Moran & Hoy, 2001, 2007). Zee and Kooman (2016) conducted a meta-analysis of over 40 years of research including 165 articles and found positive links between teacher self-efficacy and students' academic adjustment. They also found positive links to teacher behavior and teacher practices that influence classroom quality. Additionally they found links between teacher self-efficacy their psychological well-being including factors such as personal accomplishment, job satisfaction, and commitment. Self-efficacy has also been linked to positive attitudes and confidence about teaching (Guskey, 1984;

McKeown et. al., 2016), teacher stress (Greenwood et al., 1990; Parkay et al., 1988; Tschannen-Moran & Hoy, 2007), time spent teaching (Tschannen-Moran & Hoy, 2007), time spent teaching science (Riggs & Jesunathadas, 1993) and the teaching of science as inquiry (Bhattacharyya et al., 2009; McKeown et. al., 2016; Smolleck et al., 2006).

Research has linked self-efficacy to a teacher's inclination to use new teaching methods (Berman et al., 1977; Guskey, 1984; McKeown et al., 2016; Rose & Medway, 1981) and shows that teachers with low self-efficacy regarding certain topics are less likely to teach them (Chichekian & Shore, 2016; Enochs et al., 1995; Riggs & Enochs, 1990; Tschannen-Moran & Hoy, 2001, 2007). This research and its findings may be able to help explain why teachers are not implementing scientific inquiry instruction in today's classrooms despite the mandates calling for its use and the abundant research describing its effectiveness as a teaching and learning model.

Scientific Inquiry Courses

In order to increase the implementation of inquiry-based instruction in today's classrooms, it is necessary to provide teachers with guidance and opportunities to experience it (Chichekian & Shore, 2016; DiBiase & McDonald, 2015; Haim, 2003; Kleine et al., 2002; McKeown et al., 2016; Oleson & Hora, 2014; Windschitl, 2002). Courses that provide support and experience with inquiry-based instruction may help to change the self-efficacy of its students (Chichekian & Shore, 2016; Holzberger et al., 2013). Richardson and Liang (2008) found that after students were involved in scientific inquiry-based instruction, their teacher efficacy in those content areas increased. Thus, those students may be more inclined to implement scientific inquiry in their classrooms.

Thus, courses that help to increase the self-efficacy beliefs of students could be invaluable in an effort to promote the implementation of scientific inquiry teaching and learning in today's classrooms. One course that could possibly affect the self-efficacy beliefs of students regarding the teaching of science as inquiry is a course entitled Scientific Inquiry, which is currently being offered at University A. In an effort to increase the utilization of scientific inquiry instruction in today's classrooms, it would be prudent to determine whether the students in these classes experience an overall increase in self-efficacy beliefs regarding the teaching of science as inquiry as this may lead them to implement it in their classrooms.

Summary

Scientific inquiry-based instruction has been linked to increased student achievement (Anderson, 1997; Burkam et al., 1997; Carey, 1985; Feng & McComas, 2015; Freedman, 1997; Llewellyn, 2013; Lott, 1983; Shymansky, 1984; Uno, 1990; Von Secker, 2002; Von Secker & Lissitz, 1999; Wells, 1995), people skills, scientific knowledge, student motivation (Kleine et al., 2002; Llewellyn, 2013; Wells, 1995; Llewellyn, 2013), and better student attitudes (Feng & McComas, 2015; Shymansky, 1984). This research has led to a push for inquiry-based instruction in today's classrooms (AAAS, 1993; NCEE, 1983; NRC, 1996, 2000). However, scientific inquiry instruction remains a low priority for teachers (Capps & Crawford, 2012; Cigdemoglu & Köseoğlu, 2019; Costenson & Lawson, 1986; Czerniak, 1994; Damnjanovic, 1999; DiBiase & McDonald, 2015; Drayton & Falk, 2000; Hurd et al., 1980; Llewellyn, 2005; Marshall & Alston, 2014; Tal & Argaman, 2005; Wallace, 2004; Wells, 1995; Wenning, 2005; Windschitl, 2002).

Although there are numerous challenges associated with the implementation of scientific inquiry instruction, (Costenson & Lawson, 1986; DiBiase & McDonald, 2015; Wallace & Kand, 2004) a major challenge is that many teachers lack experience with it (Capps & Crawford, 2013; Kleine et al., 2002; Tamir, 1983; Windschitl, 2002). Due to this lack of experience, teachers may not believe they are properly prepared to effectively teach scientific inquiry-based lessons (Capps & Crawford, 2013; Chichekian & Shore, 2016; Hurd et al., 1980).

Self-efficacy is a construct that refers to one's beliefs in their ability to organize and perform the proper courses of action necessary to produce a result (Bandura, 1997). Research has shown that these self-efficacy results can directly influence behavior (Bandura, 1977; Ghaith & Yaghi, 1997; Gibson & Dembo, 1984; Guskey, 1988; McKeown et al., 2016; Pajares, 1992; Singer et al., 2000; Tschannen-Moran & Hoy, 2007; Windschitl, 2002) and can, more specifically, be good predictors of teacher behavior in science classrooms (Bandura, 1986; Chichekian & Shore, 2016; Hoy & Spero, 2005; McKeown et al., 2016; Riggs & Enochs, 1990; Tschannen-Moran & Hoy, 2001, 2007). Thus, an investigation of teacher self-efficacy beliefs can lead to a better understanding of teacher behavior (McKeown et al., 2016; Riggs & Enochs, 1989) because these beliefs profoundly influence behavior in the classroom (Chichekian & Shore, 2016; Fang, 1996; Hoy, 2005; Kagan, 1992; McKeown et al., 2016; Thompson, 1992; Tschannen-Moran & Hoy, 2001, 2007). A teacher with high self-efficacy in regard to the teaching of science as inquiry would be more likely to choose to use scientific inquiry in their classroom (McKeown et al., 2016; Riggs, 1995).

The support and guidance offered by a course such as Scientific Inquiry may be able to alter the self-efficacy beliefs of its participants (Chichekian & Shore, 2016; Richardson & Liang, 2008). Thus, the goal of this study was to examine the self-efficacy beliefs of students enrolled in a scientific inquiry course. This research aimed to reveal whether or not, and the extent to which, the course alters the self-efficacy beliefs of its students in regard to scientific inquiry instruction. The study also explored the role of the Mean of the pre-test means, sex, preservice status, and class year in self-efficacy. The results of this investigation help contribute to an understanding of the lack of scientific inquiry-based instruction in today's classrooms.

Chapter 3

Methodology

Purpose

The purpose of this study was to investigate the effects of the course, Scientific Inquiry, on enrolled students' self-efficacy beliefs regarding teaching scientific inquiry. This study examined whether taking the course influences the self-efficacy beliefs of students. This self-efficacy is important because students' subsequent scientific inquiry teaching may be improved because teacher beliefs contribute to teacher behavior (Chichekian & Shore, 2016; Riggs & Enochs, 1989; Tschannen-Moran & Hoy, 2007). This research specifically aimed to determine whether the self-efficacy beliefs of students can be altered through the experience gained in the scientific inquiry course. Additionally, this study examined if the Mean of the pre-test means, sex, preservice status, and class year, are related to the post-test self-efficacy score to determine if those variables mediate students' self-efficacy beliefs regarding the teaching of science as inquiry.

Research Questions

1. What are the effects of the course Scientific Inquiry on students' self-efficacy beliefs?
2. To what extent does Mean of the pre-test means, sex, preservice status, and class year predict students' post-test self-efficacy score?

Study Design

Research supports the connection between teacher self-efficacy beliefs and the implementation of scientific inquiry (Chichekian & Shore, 2016). Higher levels of self-efficacy among science teachers have been associated with greater use of scientific inquiry (Bhattacharyya et al., 2009; Chichekian & Shore, 2016; McKeown et al., 2016; Riggs, 1995; Smolleck et al., 2006; Wallace & Kand, 2004). Lower levels of self-efficacy have been associated with an avoidance of scientific inquiry teaching in favor of textbook teaching and low-risk strategies (Chichekian & Shore, 2016). Thus, in an effort to increase the implementation of scientific inquiry, which has numerous educational benefits, this study examined students' self-efficacy beliefs regarding teaching scientific inquiry.

This study examined students' self-efficacy beliefs using a quantitative quasi-experimental pre-post design. "The basic intent of an experimental design is to test the impact of a treatment (or an intervention) to an outcome" (Creswell, 2009, pp. 145-146). A quasi-experimental design is similar to a true experimental design in that it aims to evaluate the effectiveness and impact of an intervention on a population. However, a true experimental design uses random assignment of its participants. A quasi-experimental design can use both preintervention and postintervention measurements as well as nonrandomly selected groups when randomization is not feasible due to ethical or practical considerations of the participants (Gribbons & Herman, 1996).

The course, Scientific Inquiry, offers experience and support with scientific inquiry methods to its preservice teachers in a laboratory classroom. This is done by modeling scientific inquiry to students and immersing them in the methodology of scientific inquiry over the course of the entire semester. The course is taught by myself and another high school and college science teacher who has used and taught Scientific Inquiry for over seven years. The effects of the course, Scientific Inquiry, may lead to an increase in self-efficacy beliefs of students regarding the teaching of scientific inquiry (Chichekian & Shore, 2016; Smolleck & Mongan, 2011). This may lead to an increase in the implementation of scientific inquiry, which research has shown to have numerous educational advantages when compared to traditional methods of science teaching.

I administered a pre-test at the beginning of the semester to all students enrolled in the three sections of the course Scientific Inquiry from University A. The students encompass a variety of class year, age, and teaching experience but none had experience with inquiry. At the end of the course, I administered a post-test to evaluate the impact of the intervention and to explore the extent to which the course increases student self-efficacy beliefs regarding teaching scientific inquiry. Therefore, this design was appropriate because it allowed me to use the course, Scientific Inquiry, as an intervention.

Prior to the intervention, namely enrollment in the course Scientific Inquiry, students' self-efficacy beliefs regarding teaching scientific inquiry were assessed using the TSI instrument. At the conclusion of the intervention, all participants again completed the TSI instrument to measure their self-efficacy beliefs regarding teaching scientific inquiry. The data collected from both tests were examined and compared to determine whether or not there were significant differences between the mean scores for the pre-test evaluated at the beginning of the semester and the mean scores of the post-test questions evaluated at the end of the semester.

A Shapiro-Wilk Test of normality was run and revealed that the post-test data did not follow a normal distribution. The Shapiro-Wilk Test was an appropriate test to assess normality in this study due to the small sample size involved. The Shapiro-Wilk Test of normality showed that the post-test data was skewed to the right and thus was not normally distributed (Corder & Foreman, 2014).

A series of Wilcoxon Signed Rank Tests, which is a test for data that are not normally distributed, was run to determine whether there were significant differences between the scores for the pre-test and the post-test by question as well as the total scores pre-test and post-test (Corder & Foreman, 2014). A multiple regression was also inappropriate because the post-test data were not normally distributed. A Spearman's rank correlation coefficient with one tail was run because it is the one that is recommended for use with non-normal data (Corder & Foreman, 2014; Salkind, 2007). The Spearman's rank correlation coefficient with one tail was run to determine how the independent variables, Mean of the pre-test means, sex, preservice status, and class year, are related to the dependent variable, the post-test score (Salkind, 2007).

Participants

Data for this study was collected from students from University A. They were comprised of freshman, sophomore, junior, and senior levels. The participants were chosen because they were enrolled in the course Scientific Inquiry. Students can take the course at any point in their undergraduate studies.

The focus and goal of the course, Scientific Inquiry, is to offer experience and support to students regarding teaching scientific inquiry. As described in the Scientific Inquiry course syllabus (2020),

> this course for science or non-science majors introduces students to the scientific habits of mind by engaging them physically and mentally in the study of everyday life phenomenon related to science. Learners will be engaged in making observations, making inferences, asking questions, collecting data, analyzing data, and communicating results. The branches of science that are covered in this course include earth science, biology, physics, and chemistry. This course will reflect best practices for the teaching of science as outlined in the *National Science Education Standards,* the *Next Generation Science Standards,* and the ... *State Standards*. Each of these reform documents highlight scientific inquiry (or the closely related "scientific practices") as a prominent feature. As such, teaching science as inquiry will serve as the foundation of the course." To accomplish this, the course provides preservice teachers an opportunity to observe as well as directly experience being in a scientific inquiry classroom. The pre-service teachers are required to teach a Scientific Inquiry lesson in a classroom.

This study explored whether, and the extent to which experience with scientific inquiry would increase students' self-efficacy levels regarding scientific inquiry, which may make them more inclined to implement it in their classrooms. Future implementation of scientific inquiry is the rationale for offering the course. Thus, the participants were chosen based on predetermined criterion.

The Teaching Science as Inquiry (TSI) Instrument was administered within a university classroom setting in person. It was administered in three sections of the course Scientific Inquiry, which included 74 students enrolled in the course. The data collection took place at the institution, University A. I collected data on two separate occasions. Data collection took place during the month of September 2021 and again during the month of December 2021.

Instrumentation

This study utilized the TSI Instrument for data collection. The TSI Instrument is based on contemporary ideas about inquiry. The TSI instrument includes 34 items to measure personal self-efficacy in regard to implementing scientific inquiry in the classroom and 35 items to measure outcome expectancy in regard to students in a scientific inquiry classroom (Smolleck et al., 2006; Smolleck & Yoder, 2008). A 13-step process was carried out by the developers to demonstrate that the TSI Instrument sample items represented the content it intends to measure. The TSI Instrument was demonstrated to be a sound instrument when used to determine the self-efficacy beliefs of teachers regarding the teaching of scientific inquiry (Smolleck et al., 2006).

Reliability and Validity

It is important to consider reliability and validity when selecting the measurement instrument for the data collection portion of this research in order to maintain the trustworthiness of its results. Reliability is described as the internal consistency or stability of an instrument over time. Reliability can be increased by lengthening the number of items on an instrument. In other words, more items in an instrument lead to a better estimate of a participants' true score (Borg & Gall, 1989). The TSI Instrument consists of 69 items. This significant number of items helps to increase the reliability of the TSI instrument while still maintaining the two-constructs of self-efficacy in regard to the teaching of scientific inquiry (Smolleck et al., 2006).

Test reliability most often involves the computation of a correlation coefficient between two sets of similar measurements. It can be determined three ways: coefficient of equivalence, coefficient of stability, and coefficient of internal consistency. The coefficient of equivalence calculates the reliability of an instrument when two or more parallel forms are available. The tests are administered to the same group and their scores are correlated yielding a reliability coefficient. The coefficient of stability calculates reliability of an instrument given to its participants before and after a delay in time. The delay in time may lead to participants being in a different mood, remembering less, or being more tired making it difficult to guarantee similar conditions (Borg & Gall, 1989).

The coefficient of internal consistency calculates reliability from a single administration of a single form of an instrument. Because certain items on a single test may discriminate in favor of some students and against other students, this coefficient may need to be addressed for some instruments (Borg & Gall, 1989). However, the TSI Instrument covers a broad range of items and is composed of 69 questions in order to address this notion.

Because the TSI Instrument is administered as a single test, its reliability is computed using the coefficient of internal consistency. Additionally, since the TSI Instrument includes items that have several possible answers each of which is given a different weight ranging from strongly agree to strongly disagree, Cronbach’s coefficient alpha is an appropriate method for computing reliability (Borg & Gall, 1989). The TSI Instrument “overall reliability scores in relation to self-efficacy were: pretest a of .9441 and a post-test a of .8911. The overall reliability scores in relation to outcome expectancy were: pre-test a of .9023 and posttest a of .9029” (Smolleck & Yoder, 2008, p. 294). Further, the developers ensured reliability by eliminating any items that were not directly contributing to the reliability of the instrument and they examined item balance across the 24 variations of the essential features of scientific inquiry (Smolleck & Yoder, 2008). Thus, the TSI Instrument has been shown to be valid and reliable to measure self-efficacy beliefs in regard to the teaching of scientific inquiry (Smolleck et al., 2006).

Validity is described as how well a specific test actually measures what it says it measures (Borg & Gall, 1989). This study aims to measure the self-efficacy of students regarding the teaching of scientific inquiry. As such, it required a valid instrument that actually measured the self-efficacy beliefs of teachers regarding the teaching of scientific inquiry. The instrument had to be valid so the data and results obtained would be valid. Validity relates to the soundness of the research (Graziano & Raulin, 2000). It aims to determine whether the inferences made from the data can be considered useful and meaningful. Test validity can be determined four ways: content validity, construct validity, predictive validity, and concurrent validity (Isaac & Michael, 1997; Popham, 2000).

Content validity describes how well the test items represent the content the test intends to measure (Borg & Gall, 1989). The TSI Instrument intends to measure Bandura’s (1977) two dimensions of self-efficacy, personal self-efficacy and outcome expectancy, regarding the teaching of scientific inquiry. Personal self-efficacy relates to one's judgment of one's capability to organize and execute the courses of action necessary to achieve certain results. Outcome expectancy refers to one's judgment regarding what consequences they expect those results to produce (Bandura, 1977). In terms of the TSI instrument, personal self-efficacy refers to the students' judgment of their ability to teach scientific inquiry. Alternately, outcome expectancy refers to the consequences they expect from teaching scientific inquiry. The TSI Instrument used in this research exhibited content validity (Smolleck et al., 2006).

Construct validity describes how well a test can measure a hypothetical construct. A hypothetical construct is presumed to exist despite not being directly observable and may be inferred by how it effects behavior. Examples of hypothetical constructs include intelligence, level of emotion, or creativity (Borg & Gall, 1989; Krathwohl, 1998). Self-efficacy was the construct investigated in this research, so it is important to determine its construct validity to ensure that the test measures it accurately. Additionally, self-efficacy is a situation-specific construct (Bandura, 1981) so this research needed a situation-specific instrument that could measure self-efficacy beliefs regarding the teaching of scientific inquiry. As such, the TSI Instrument is construct valid because if measures self-efficacy beliefs accurately (Smolleck et al., 2006).

Predictive validity describes how well the future behavior of the subjects matches the predictions made by the test (Borg & Gall, 1989). Further research, in terms of a follow-up study could be used to check for the predictive validity of the TSI Instrument. Students with low self-efficacy regarding the teaching of scientific inquiry should be less likely to use it in their future classrooms if the survey has predictive validity. Students with high self-efficacy regarding the teaching of scientific inquiry would be more likely to use it. Thus, future observation and interviews of these students could be used to determine whether their self-efficacy scores correlated with their implementation or avoidance of scientific inquiry instruction.

Concurrent validity describes how well the test scores of a group of subjects relates to a criterion measured at the same time or within a short period of time (Borg & Gall, 1989). Only one test at a time was administered in this study and there was no attempt to relate those scores to another criterion measured concurrently.

Additionally, the TSI Instrument was developed incorporating Bandura's (1981) notion that self-efficacy is a situation-specific construct. The level of self-efficacy in one domain is not always indicative of the level of self-efficacy in another domain. One of the students in this study could, for example, have high self-efficacy in regard to their mathematics skills yet low self-efficacy in regard to reading and writing skills (Stage et al., 1998). The TSI instrument specifically focuses on the self-efficacy beliefs of teachers regarding the teaching of scientific inquiry. It connects self-efficacy and scientific inquiry teaching and learning (Smolleck et al., 2006). Thus, the TSI instrument was used for this research because it focuses on the self-efficacy beliefs of teachers regarding the teaching of scientific inquiry.

The TSI Instrument was designed for use with preservice teachers by Smolleck (2004). Sample TSI instrument questions such as #3 "I am able to encourage my students to independently examine resources in an attempt to connect their explanations to scientific knowledge," #10 "I am able to provide opportunities for students to become the critical decision makers when evaluating the validity of scientific explanations," and #26 "I possess the skills necessary for guiding my students toward explanations that are consistent with experimental and observational evidence" examine self-efficacy levels in general as opposed to being intended for use only at a certain level of teaching or for a certain number of years of teacher experience. The TSI Instrument was developed to measure the self-efficacy beliefs of teachers regarding the teaching of scientific inquiry as defined by the NRC (1996) where it can be applied across all levels of instruction. Therefore, these questions can measure teacher self-efficacy for preservice teachers which makes the TSI Instrument appropriate for this research.

Data Analysis

The purpose of this study was to examine whether the course, Scientific Inquiry, influences the self-efficacy beliefs of students regarding teaching scientific inquiry. I hypothesized that students who take the course will have higher self-efficacy beliefs regarding teaching scientific inquiry than they had prior to taking the course. Specifically, I compared the mean scores of the self-efficacy beliefs pre-test questions evaluated at the beginning of the semester with the mean scores of the self-efficacy beliefs post-test questions evaluated at the end of the semester to determine whether or not there were significant differences in students self-efficacy beliefs regarding the teaching of science as inquiry.

A Shapiro-Wilk Test of normality was run and revealed post-test data was not normally distributed (Corder & Foreman, 2014). A series of Wilcoxon Signed Rank Tests, which is a test for data that are not normally distributed, was then run to determine whether there were significant differences between the scores for the pre-test and the post-test by question as well as the total scores pre-test and post-test (Corder & Foreman, 2014). Additionally, a Spearman's rank correlation coefficient with one tail, recommended for use with non-normal data, was run (Corder & Foreman, 2014; Salkind, 2007). The Spearman's rank correlation coefficient with one tail was run to determine how the independent variables, Mean of the pre-test means, sex, preservice status, and class year, are related to the dependent variable, the post-test score of students' self-efficacy beliefs regarding the teaching of science as inquiry (Salkind, 2007).

This study examined the pre-test and post-test mean scores by sex to explore any differences that may emerge. The majority of public school teachers are female (US Department of Commerce Executive Summary, 2011) and females tend to believe their success in science courses to be lower than males (Betz & Hackett, 1997; Britner & Pajares, 2001, 2006; Kupermintz, 2002; Lau & Roeser, 2002; Pajares, 1997; Rayburn, 2009; Zeldin et al., 2008). An increase in female self-efficacy levels could significantly increase the implementation of higher level science education strategies such as scientific inquiry. Additionally, women remain underrepresented in the science, technology, engineering and math (STEM) workforce (US Department of Commerce Executive Summary, 2011). Further, an investigation into the role of sex on self-efficacy may help explain the lack of women in science. This may also help to expand STEM employment in the United States as well as contribute to an increase in global competitiveness. (Beede et al., 2011). The study also examined the role of preservice status of participants on students' self-efficacy beliefs regarding the teaching of science as inquiry. Additionally, the study examined the role of class year on students' self-efficacy beliefs regarding the teaching of science as inquiry.

Researcher Positionality

I am a professor of Scientific Inquiry at a university. As a former high school physics teacher and education researcher, I was introduced to the methodology of Scientific Inquiry as well as its effectiveness. I have spent the last nine years teaching Scientific Inquiry. I believe that the experience gained in the course encourages students to model effective instruction in their future classrooms, thus promoting success for their students. For my doctoral work through Rowan University, I became very interested in exploring the effectiveness of this course through an examination of student self-efficacy beliefs because higher self-efficacy may encourage the implementation of scientific inquiry. Thus, I was very interested to see the effects of the course on the self-efficacy beliefs of the enrolled students regarding teaching scientific inquiry.

This study examined students' self-efficacy beliefs regarding the teaching of scientific inquiry. It aims to specifically evaluate the impact of the intervention, the course Scientific Inquiry, on its students. The course offers experience and guidance with scientific inquiry methods to its preservice teachers in a laboratory classroom. This is accomplished through teacher modeling of scientific inquiry to students and by immersing them in scientific inquiry methods over the course of a college semester. The course may lead to an increase in self-efficacy beliefs of students regarding the teaching of scientific inquiry. This may ultimately lead to an increase in the implementation of scientific inquiry in classrooms which research has shown to have many educational advantages when compared to traditional methods of science teaching.

Chapter 4

Findings

This study examined the self-efficacy beliefs of students enrolled in the course Scientific Inquiry using a quantitative quasi-experimental pre-post-test design. This study aimed to reveal whether or not the course influences the self-efficacy beliefs of its students in regard to teaching scientific inquiry. This is important because an increase in self-efficacy beliefs may lead to the implementation of scientific inquiry in classrooms, which research has shown to have many educational benefits (Anderson, 1997; Burkam et al., 1997; Carey, 1985; Feng & McComas, 2015; Freedman, 1997; Lott, 1983; Schmidt et al., 2002; Shymansky, 1984; Uno, 1990; Von Secker, 2002; Von Secker & Lissitz, 1999; Wells, 1995).

The TSI Instrument was used to assess student self-efficacy beliefs (Smolleck et al., 2006). The instrument was administered as a pre-test survey at the beginning of the semester to the students enrolled in the three sections of the course, Scientific Inquiry, from University A. The instrument was again administered as a post-test survey at the end of the semester. This was done to examine whether there were significant differences between the mean scores for the pre-test and the mean scores of the post-test questions. The sample size was 74 for students who completed the pre-test survey and the sample size was 66 for students who completed the post-test survey. Participant data is presented below.

Table 1

Number of Participants by Sex

	Male	Female
Sex	29	45

Table 2

Number of Participants by Preservice Status

	Preservice	Non-Preservice
Preservice status	20	54

Table 3

Number of Participants by Class Year

	Freshman	Sophomore	Junior	Senior
Class Year	2	17	39	16

A paired sample t-test was initially used to determine the significance of the results of the study (Corder & Foreman, 2014; Salkind, 2007). Once I started working with the data, it was clear that I had to readjust the plan for data analysis. The pre-test data were normally distributed. However, further testing for normality using the Shapiro-Wilk Test revealed that the post-test data did not follow a normal distribution. The Shapiro-Wilk Test was an appropriate test to assess normality in this study due to the small sample size involved. The Shapiro-Wilk Test showed that the post-test data was skewed to the right. The Shapiro-Wilk Test of normality revealed that the data was not normally distributed (Corder & Foreman, 2014). The results are presented below.

Table 4

Test of Normality: Shapiro-Wilk Test

	Significance
Post-test Total Score	.032

Normal≥.05

Thus, running a nonparametric test was necessary as an alternative to the paired sample t-test (Corder & Foreman, 2014; Salkind, 2007). The Wilcoxon Signed Rank Test was the nonparametric alternative to the paired sample t-test used in data analysis (Corder & Foreman, 2014). A series of Wilcoxon Signed Rank Tests was run to determine whether there were significant differences between the scores for the pre-test and the post-test by question. The findings of this investigation help contribute to an understanding of the lack of scientific inquiry-based instruction in today's classrooms and answer the following research questions:

Research Questions

1. What are the effects of the course Scientific Inquiry on students' self-efficacy beliefs?
2. To what extent does Mean of the pre-test means, sex, preservice status, and class year predict students' post-test self-efficacy score?

In order to develop the findings of this study, I initially ran a series of tests. The Mean of the pre-test means was 3.5174. The Mean of the post-test means was 4.2587. I ran a t-test on the Mean scores as well. The t-test on the Mean scores shows a significant increase from the pre-test to the post-test and was significant at the .001 level.

I then ran multiple linear regression on the data to test if the independent variables, the overall pre-test score, sex, preservice status, and class year, significantly predicted the dependent variable, the overall post-test score. The regression model was not significant and none of the independent variables significantly predicted the overall post-test score. I began to explore the reasons for this result and ran a series of tests to investigate the normality of the distribution of the data, and I quickly realized the post-test data were not normally distributed (Salkind, 2007).

Based on the skewed results of the Shapiro-Wilk normality test, I ran a series of Wilcoxon Signed Rank Tests, which is a test for data that are not normally distributed, to determine whether there were significant differences between the scores for the pre-test and the post-test by question (Corder & Foreman, 2014). The results for each question were all significant and positive except for Question 47, which was not significant. I also ran Wilcoxon Signed Rank Tests on the Mean of the pre-test and Mean of the post-test mean scores as well as the total scores pre-test and post-test. The results for both were significant. All of the results are presented below. I am reporting five questions in each table to better manage the formatting.

Table 5

TSI Questions 1-5

Text	Pre-Mean	Post-Mean	Significance
Question 1: I will be able to offer multiple suggestions for creating explanations from data.	3.34	4.26	0.000***
Question 2: I will be able to provide students with the opportunity to construct alternative explanations for the same observations.	3.43	4.30	0.000***
Question 3: I will be able to encourage my students to independently examine resources in an attempt to connect their explanations to scientific knowledge.	3.69	4.30	0.000***
Question 4: I possess the ability to provide meaningful common experiences from which predictable scientific questions are posed by students.	3.23	4.00	0.000***
Question 5: I have the necessary skills to determine the best manner through which children can obtain scientific evidence.	2.91	4.02	0.000***

*≤.05**≤.01***≤.001

Questions 1-5 all show a significant increase from the pre-test to the post-test and all are at the .001 level.

Table 6

TSI Questions 6-10

Text	Pre-Mean	Post-Mean	Significance
Question 6: I will require students to defend their newly acquired knowledge during large and/or small group discussions.	3.78	4.33	0.000***
Question 7: My students will select among a list of given questions while investigating scientific phenomena.	3.47	3.86	0.009**
Question 8: I will provide opportunities through which children will obtain evidence from observations and measurements.	3.62	4.41	0.000***
Question 9: I will expect my students to make the results of their investigations public.	3.01	3.77	0.000***
Question 10: I will be able to provide opportunities for students to become the critical decision makers when evaluating the validity of scientific explanations.	3.70	4.35	0.000***

*≤.05**≤.01***≤.001

Questions 6-10 all show a significant increase from the pre-test to the post-test and all are at the .001 level except Question 7, which is at the .01 level.

Table 7

TSI Questions 11-15

Text	Pre-Mean	Post-Mean	Significance
Question 11: I will be able to guide students in asking scientific questions that are meaningful.	3.68	4.42	0.000***
Question 12: I will be able to provide opportunities for my students to describe their investigations and findings to others using their evidence to justify and how data was collected explanations.	3.66	4.42	0.000***
Question 13: I will create (plan) investigations through which students will be expected to gather particular evidence.	3.54	4.32	0.000***
Question 14: I will be able to negotiate with students possible connections between/among explanations.	3.46	4.11	0.000***
Question 15: I will expect students to independently develop explanations using what they already know about scientifically accepted ideas.	3.57	4.36	0.000***

*≤.05**≤.01***≤.001

Questions 11-15 all show a significant increase from the pre-test to the post-test and all are at the .001 level.

Table 8

TSI Questions 16-20

Text	Pre-Mean	Post-Mean	Significance
Question 16: I encompass the ability to encourage students to review and ask questions about the results of other students' work.	3.80	4.36	0.000***
Question 17: I will be able to guide students toward appropriate investigations depending on the questions they are attempting to answer.	3.62	4.24	0.000***
Question 18: I will be able to create the majority of scientific questions needed for students to investigate.	2.91	4.12	0.000***
Question 19: I possess the ability to allow students to devise their own problems to investigate.	3.28	4.23	0.000***
Question 20: My students will make use of data in order to develop explanations as a result of teacher guidance.	3.66	4.32	0.000***

*≤.05**≤.01***≤.001

Questions 16-20 all show a significant increase from the pre-test to the post-test and all are at the .001 level.

Table 9

TSI Questions 21-25

Text	Pre-Mean	Post-Mean	Significance
Question 21: I will be able to play the primary role in guiding the identification of scientific questions.	3.20	4.24	0.000***
Question 22: I will be able to guide students toward scientifically accepted ideas upon which they can develop more meaningful understandings of science.	3.31	4.26	0.000***
Question 23: I possess the abilities necessary to provide students with the possible connections between scientific knowledge and their explanations.	3.09	4.12	0.000***
Question 24: I will expect students to recognize the connections existing between proposed explanations and scientific knowledge.	3.41	4.29	0.000***
Question 25: I will expect students to ask scientific questions.	4.07	4.39	0.007**

*≤.05**≤.01***≤.001

Questions 21-25 all show a significant increase from the pre-test to the post-test and all are at the .001 level except for Question 25, which is at the .01 level.

Table 10

TSI Questions 26-30

Text	Pre-Mean	Post-Mean	Significance
Question 26: I possess the skills necessary for guiding my students toward explanations that are consistent with experimental and observational evidence.	2.97	4.14	0.000***
Question 27: My students will investigate questions I have developed.	3.54	4.24	0.000***
Question 28: My students will develop scientific explanations based on evidence, as a result of teacher assistance.	3.76	4.45	0.000***
Question 29: My students will derive scientific evidence from instructional materials such as a textbook.	3.42	4.06	0.000***
Question 30: I will be able to encourage students to gather the appropriate data necessary for answering their questions.	3.85	4.47	0.000***

*≤.05**≤.01***≤.001

Questions 26-30 all show a significant increase from the pre-test to the post-test and all are at the .001 level.

Table 11

TSI Questions 31-35

Text	Pre-Mean	Post-Mean	Significance
Question 31: I will be able to offer/model approaches for generating explanations from evidence.	3.45	4.32	0.000***
Question 32: I will be able to coach students in the clear articulation of explanations.	3.39	4.20	0.000***
Question 33: Through the process of sharing explanations, I will be able to provide students with the opportunity to critique explanations and investigation methods.	3.47	4.21	0.000***
Question 34: I will require students to create scientific claims based on observational evidence.	3.64	4.15	0.000***
Question 35: I will expect my students to think about other reasonable explanations that can be derived from the evidence presented.	3.72	4.35	0.000***

*≤.05**≤.01***≤.001

Questions 31-35 all show a significant increase from the pre-test to the post-test and all are at the .001 level.

Table 12

TSI Questions 36-40

Text	Pre-Mean	Post-Mean	Significance
Question 36: I will be able to facilitate open-ended, long-term student investigations in an attempt to provide opportunities for students to gather evidence.	3.31	3.98	0.000***
Question 37: I will be able to help students refine questions posed by the teacher or instructional materials, so they can experience both interesting and productive investigations.	3.49	4.32	0.000***
Question 38: I will be able to provide demonstrations through which students can focus their queries into manageable questions for investigation.	3.31	4.27	0.000***
Question 39: I will require students to develop explanations using evidence.	4.03	4.41	0.002**
Question 40: I will be able to utilize worksheets as an instructional tool for providing a data set and walking students through the analysis process.	3.65	4.18	0.000***

*≤.05**≤.01***≤.001

Questions 36-40 all show a significant increase from the pre-test to the post-test and all are at the .001 level except for Question 39, which is at the .01 level.

Table 13

TSI Questions 41-45

Text	Pre-Mean	Post-Mean	Significance
Question 41: My students will refine their explanations using possible connections to scientific knowledge that have been provided.	3.65	4.26	0.000***
Question 42: I will be able to model for my students prescribed steps or procedures for communicating scientific results to the class.	3.58	4.35	0.000***
Question 43: I will be able to provide my students with possible connections to scientific knowledge through which they can relate their explanations.	3.50	4.30	0.000***
Question 44: I will be able to provide my students with evidence to be analyzed.	3.73	4.41	0.000***
Question 45: My students will engage in questions I have provided them.	4.05	4.42	0.001***

$*\leq.05**\leq.01***\leq.001$

Questions 41-45 all show a significant increase from the pre-test to the post-test and all are at the .001 level.

Table 14

TSI Questions 46-50

Text	Pre-Mean	Post-Mean	Significance
Question 46: My students will engage in questions that are provided by a variety of sources such as the textbook.	3.68	4.14	0.001***
Question 47: My students will analyze data that has been supplied, while following teacher instruction.	3.92	4.17	0.073
Question 48: I will expect my students to clarify the questions provided in an attempt to enhance science learning.	3.76	4.32	0.000***
Question 49: I will be able to provide my students with the data needed to support an investigation.	3.69	4.41	0.000***
Question 50: My students will communicate and justify their explanations to the class using broad guidelines that have been provided.	3.70	4.47	0.001***

*≤.05**≤.01***≤.001

Questions 46-50 all show a significant increase from the pre-test to the post-test and all are at the .001 level except for Question 47, which was not significant.

Table 15

TSI Questions 51-55

Text	Pre-Mean	Post-Mean	Significance
Question 51: My students will choose the questions they would like to investigate from a list provided.	3.69	4.14	0.007**
Question 52: My students will analyze teacher provided data in a particular manner.	3.49	4.09	0.000***
Question 53: My students will form their explanations using evidence that has been provided.	3.78	4.21	0.003**
Question 54: I will be able to provide my students with all evidence required to form explanations through the use of lecture and textbook readings.	3.54	4.14	0.000***
Question 55: My students will construct explanations from evidence using a framework I have provided.	3.55	4.15	0.000***

*≤.05**≤.01***≤.001

Questions 51-55 all show a significant increase from the pre-test to the post-test and all are at the .001 level except for Question 51 and Question 53, which are both at the .01 level.

Table 16

TSI Questions 56-60

Text	Pre-Mean	Post-Mean	Significance
Question 56: I will expect my students to follow predetermined procedures when justifying their explanations.	3.57	4.03	0.001***
Question 57: My students will determine what evidence will be more useful for answering their scientific question(s).	3.88	4.39	0.000***
Question 58: My students will design their own investigations and gather the evidence necessary to answer a particular question.	3.55	4.30	0.000***
Question 59: I will expect my students to collaborate with me in an attempt to construct criteria for sharing and critiquing explanations.	3.46	4.45	0.000***
Question 60: My students will share and critique explanations while utilizing broad guidelines that have been provided.	3.47	4.35	0.000***

*≤.05**≤.01***≤.001

Questions 56-60 all show a significant increase from the pre-test to the post-test and all are at the .001 level.

Table 17

TSI Questions 61-65

Text	Pre-Mean	Post-Mean	Significance
Question 61: I will expect students to use internet based resources or other materials to further develop their investigations.	3.70	4.29	0.001***
Question 62: I will be able to model for my students the guidelines to be followed when sharing and critiquing explanations.	3.34	4.32	0.000***
Question 63: I will be able to instruct students to independently evaluate the consistency between their own explanations and scientifically accepted ideas.	3.27	4.39	0.000***
Question 64: I will expect my students to negotiate with me the criteria for sharing and critiquing explanations.	3.38	4.18	0.000***
Question 65: I will be able to construct with students the guidelines for communicating results and explanations.	3.19	4.29	0.000***

*≤.05**≤.01***≤.001

Questions 61-65 all show a significant increase from the pre-test to the post-test and all are at the .001 level.

Table 18

TSI Questions 66-69

Text	Pre-Mean	Post-Mean	Significance
Question 66: I will expect my students to refine questions that have been provided.	3.38	4.12	0.000***
Question 67: I will be able to provide my students with explanations.	3.28	4.48	0.000***
Question 68: I will expect my students to justify explanations using given steps and procedures.	3.54	4.33	0.000***
Question 69: My students will comprehend teacher presented explanations.	3.58	4.36	0.000***

*≤.05**≤.01***≤.001

Finally, Questions 66-69 all show a significant increase from the pre-test to the post-test and all are at the .001 level. The results above were all significant except for Question 47, which was not significant.

I ran Wilcoxon Signed Rank Tests on the Mean of the pre-test and Mean of the post-test mean. The results were significant and are presented below.

Table 19

Wilcoxon Signed Rank Tests Mean Results

Pre-test Mean	Post-test Mean	Significance
3.52	4.26	0.001***

*≤.05**≤.01***≤.001

I also ran Wilcoxon Signed Rank Tests on the total scores pre-test and post-test. The results were significant and are presented below.

Table 20

Wilcoxon Signed Rank Tests Total Score Results

Pre-test Total Score	Post-test Total Score	Significance
242.70	293.55	0.001***

*≤.05**≤.01***≤.001

I was unable to run a multiple regression because the post-test data were not normally distributed. Instead, I ran a correlation to determine how the independent variables, Mean of the pre-test means, sex, preservice status, and class year, are related to the dependent variable, the post-test score. Specifically, I ran a Spearman's rank correlation coefficient with one tail because it is the one that is recommended for use with non-normal data (Corder & Foreman, 2014; Salkind, 2007).

The data revealed that preservice status and sex are negatively and significantly correlated to each other at -.302 and are at the 0.01 level. This finding follows the 2016 report by the National Center for Education Statistics that found 24% of public school teachers are male and that men are much less likely to be going into teaching. The data also revealed that the pre-test total score and the post-test total score are positively and significantly correlated at .227 and are at the .05 level, a finding that is supported by the hypothesis of this study which was that students who take the course, Scientific Inquiry, will have higher self-efficacy beliefs regarding teaching scientific inquiry than they had prior to taking the course. All of the data is presented below.

Table 21

Spearman's Rank Correlation Coefficient Data

	Sex	Preservice Status	Class Year	Post-test Total Score	Pre-test Total Score
Sex	1.000	-.302**	-.147	-.054	-.086
Preservice Status	-.302**	1.000	.101	-.067	-.031
Class Year	-.147	.101	1.000	-.018	.030
Post-test Total Score	-.054	-.067	-.018	1.000	.227*
Pre-test Total Score	-.086	-.031	.030	.227*	1.00

*≤.05**≤.01***≤.001

This study investigated whether or not the course, Scientific Inquiry, influences the self-efficacy beliefs of its students in regard to teaching scientific inquiry. Theory supports the notion that one's chosen behaviors and decisions align with one's beliefs (Bandura, 1977; Ghaith & Yaghi, 1997; Gibson & Dembo, 1984; Guskey, 1988; Pajares, 1992; Singer et al., 2000; Windschitl, 2002). Thus, investigating the beliefs of teachers is a valid way to determine what they may or may not do in their classrooms. Because an increase in self-efficacy beliefs may lead teachers to use scientific inquiry in their classrooms, which research has shown to be educationally advantageous (Anderson, 1997; Burkam et al., 1997; Carey, 1985; Feng & McComas, 2015; Freedman, 1997; Lott, 1983; Schmidt et al., 2002; Shymansky, 1984; Uno, 1990; Von Secker, 2002; Von Secker & Lissitz, 1999; Wells, 1995), this is a worthwhile investigation. This study did see significant growth in students regarding their self-efficacy beliefs in regard to teaching scientific inquiry. Chapter 5 will further discuss the analysis of the data presented above.

Chapter 5

Analysis, Discussion, Implications

Analysis

This quantitative, pre-post-test study examined the impacts of the course, Scientific Inquiry, on the self-efficacy beliefs of its students. The Teaching Science as Inquiry (TSI) Instrument was used to measure student self-efficacy beliefs as a pre-test survey at the beginning of the semester. It was again administered as a post-test survey at the end of the semester. I examined student self-efficacy beliefs to reveal whether there were significant differences between the mean scores for the pre-test evaluated at the beginning of the semester and the mean scores of the post-test questions evaluated at the end of the semester. The sample size was 74 for students who completed the pre-test survey and the sample size was 66 for students who completed the post-test survey. Data from the teaching science as inquiry (TSI) instrument was analyzed using descriptive statistics.

I ran a series of Wilcoxon Signed Rank Tests, which is a test for data that are not normally distributed, to determine whether there were significant differences between the scores for the pre-test and the post-test by question (Corder & Foreman, 2014). The results for each question were all significant and positive except for one, Question 47. These significant results indicate that self-efficacy beliefs regarding the teaching of scientific inquiry are malleable and can be increased as a result of experience with scientific inquiry gained as a student in the Scientific Inquiry course.

This study also examined whether or not there was a significant difference between the Mean of the pre-test means and the Mean of the post-test means. I ran additional Wilcoxon Signed Rank Tests on the Mean of the pre-test and Mean of the post-test mean scores. The Mean of the pre-test means was 3.5174. The Mean of the post-test means was 4.2587. I also ran Wilcoxon Signed Rank Tests on the total scores pre-test and post-test. The results for both were significant. These results indicate that the course, Scientific Inquiry, does significantly increase the self-efficacy beliefs of students regarding the teaching of science as inquiry. Thus, the course may help to address the overarching problem regarding the low priority of scientific inquiry in today's classrooms. This will allow teachers to lead the next generation of students responsibly and successfully in effective science lessons (Llewellyn, 2013).

Two research questions were developed in order to investigate the self-efficacy beliefs of students regarding the teaching of scientific inquiry. Research Question 1 of this dissertation is "What are the effects of the course Scientific Inquiry on students' self-efficacy beliefs?" The results indicate that the course Scientific Inquiry led to an increase in student self-efficacy beliefs regarding the teaching of science as inquiry. The course does significantly increase the self-efficacy beliefs of students regarding the teaching of science as inquiry, as indicated by the significant Wilcoxon Signed Rank Tests. Self-efficacy beliefs drastically influence the decisions teachers make (Chichekian & Shore, 2016; DiBiase & McDonald, 2015). Bandura's (1977) social learning theory supports the idea that an increase in self-efficacy beliefs from a course like Scientific Inquiry, which provides an opportunity to experience inquiry-based instruction, will lead to teachers feeling more comfortable implementing scientific inquiry in their own classrooms. Thus, students who take the course Scientific Inquiry may be more inclined to use scientific inquiry in their classrooms.

This study also examined the relationship between the independent variables, the Mean of the pre-test means, sex, preservice status, and class year, and the dependent variable, the Mean of the post-test means. Research Question 2 of this dissertation is "to what extent do sex, preservice status, and year of college predict students' post-test self-efficacy score?" I ran a Spearman's rank correlation coefficient with one tail to determine how the independent variables, Mean of the pre-test means, sex, preservice status, and class year, are related to the dependent variable, the post-test score (Salkind, 2007). The data revealed that preservice status and sex are negatively and significantly correlated to each other at -.302 and are at the 0.01 level, which is expected because males are much less likely than females to become teachers (National Center for Education Statistics, 2022). The data also revealed that the pre-test total score and the post-test total score are positively and significantly correlated at .227 and are at the .05 level, but none of the other independent variables were significantly correlated with the post-test Mean. Thus, the independent variables do not mediate the post-test self-efficacy score of participants.

The sample size of this study could help in part to explain why none of the independent variables predicted the dependent variable. Other possible reasons for none of the independent variables mediating the Mean of the post-test means are that it is actual experience with scientific inquiry that matters (Chichekian & Shore, 2016; Damnjanovic, 1999). Other research conducted found no correlation between inquiry instruction and other factors such as the number of years taught, the highest degree held by the teacher, and the prior educational and work experiences (Chichekian & Shore, 2016). It is possible, as found by this study, that opportunities to experience scientific inquiry, which students in the course experience, lead to an increase in self-efficacy beliefs regarding the teaching of scientific inquiry and that other variables, such as the demographic factors investigated, do not.

Discussion

This study examined the course, Scientific Inquiry, specifically to examine whether or not it influences self-efficacy. This was examined using the TSI Instrument to measure self-efficacy beliefs of students before and after taking the course. The TSI Instrument allows for the comparison of individual question pre and post-test means as well as the Mean of the pre-test means to the Mean of the post-test means. The results of this study indicate that the course, Scientific Inquiry, does play a significant role in increasing the self-efficacy beliefs of students regarding the teaching of science as inquiry and thus may help to increase the implementation of scientific inquiry in today's classrooms.

Scientific inquiry as a teaching and learning method has numerous educational benefits (Feng & McComas, 2015; Schmidt et al., 2002; Shymansky, 1984; Uno, 1990; Von Secker, 2002; Von Secker & Lissitz, 1999; Wells, 1995), yet its visibility in today's science classrooms remains low (Capps & Crawford, 2012; Cigdemoglu & Köseoğlu, 2019; Damnjanovic, 1999; DiBiase & McDonald, 2015; Drayton & Falk, 2000; Hurd et al., 1980; Llewellyn, 2005; Marshall & Alston, 2014; Smolleck & Nordgren, 2014; Tal & Argaman, 2005; Wenning, 2005; Windschitl, 2002). One main reason for its lack of presence is the fact that many of today's science teachers lack experience with scientific inquiry (Costenson & Lawson, 1986; DiBiase & McDonald, 2015; Kleine et al., 2002; NRC, 2000; Tamir, 1983; Windschitl, 2002). The lack of experience makes it difficult for teachers to implement scientific inquiry into their classrooms (Chichekian & Shore, 2016; Damnjanovic, 1999) because they do not have the confidence and do not believe they can lead inquiry-based investigations (DiBiase & McDonald, 2015; Hurd et al., 1980).

Improving teacher confidence and more specifically, increasing teacher self-efficacy beliefs regarding scientific inquiry teaching, is an important component in making it a priority in today's science classrooms (Chichekian & Shore, 2016). Bandura's social learning theory (1977) supports the notion that modeling and successful experiences can lead to an increase in self-efficacy beliefs. Self-efficacy beliefs, in turn, influence teacher behavior (DiBiase & McDonald, 2015; Fang, 1996; Fishman et al., 2003; Kagan, 1992; Khanshan & Yousefi, 2020; Thompson, 1992; Tschannen-Moran & Woolfolk-Hoy, 2001, 2007; Wallace & Kand, 2004; Woolfolk-Hoy & Spero, 2005). Self-efficacy beliefs can help predict how willing teachers are to use new teaching methods (Berman et al., 1977; Guskey, 1984; McKeown et al., 2016; Rose & Medway, 1981) and how likely they are to teach certain topics (Chichekian & Shore, 2016; Enochs et al., 1995; Riggs & Enochs, 1990; Tschannen-Moran & Hoy, 2001, 2007).

One way to increase teacher confidence and self-efficacy beliefs regarding scientific inquiry teaching is by providing teachers with opportunities to experience it (Charalambous & Philippou, 2010; Chichekian & Shore, 2016; Liang & Richardson, 2009) as the course Scientific Inquiry does. When teachers gain experience with a construct such as scientific inquiry, they are more likely to experience success, which in turn increases their self-efficacy level regarding that construct (Holzberger et al., 2013).

Opportunities that provide experience are the most influential way to change a teachers' self-efficacy beliefs (Brand & Wilkins, 2007). Because teachers tend to model their teaching after previous instructors and experiences (Johnson, 2006; Oleson & Hora, 2014; Singer et al., 2006), the course, Scientific Inquiry, provides students with the opportunity to experience scientific inquiry as a means to increase their self-efficacy beliefs, which may lead them to utilize it in their future classrooms.

Scientific inquiry was developed based on research and experience regarding how students learn best (National Research Council, 2012). It has been shown to have numerous advantages and benefits in educational settings (Feng & McComas, 2015; Schmidt et al., 2002; Von Secker, 2002) such as higher student achievement (Feng & McComas, 2015; Marshall & Alston, 2014), increased scientific knowledge growth and motivation (Llewellyn, 2013), and better student attitudes (Feng & McComas, 2015). However, teachers simply are not implementing it (Capps & Crawford, 2012; Cigdemoglu & Köseoğlu, 2019; DiBiase & McDonald, 2015; Marshall & Alston, 2014; Tal & Argaman, 2005; Wenning, 2005) because they lack experience with scientific inquiry (DiBiase & McDonald, 2015; Kleine et al., 2002; NRC, 2012).

The course, Scientific Inquiry, was developed to improve science instruction and education by providing students with necessary experience with scientific inquiry. According to Bandura's social learning theory (1977), this experience can lead to an increase in self-efficacy beliefs which have been shown to influence teacher behavior (DiBiase & McDonald, 2015; Fang, 1996; Fishman et al., 2003; Kagan, 1992; Khanshan & Yousefi, 2020; Thompson, 1992; Tschannen-Moran & Woolfolk-Hoy, 2001, 2007; Wallace & Kand, 2004; Woolfolk-Hoy & Spero, 2005). Higher self-efficacy beliefs regarding the teaching of science as inquiry may encourage its implementation in classrooms. As such, this study demonstrated that the course Scientific Inquiry increased the self-efficacy beliefs of students regarding teaching science as inquiry.

Limitations

The results of this study are viable and contribute to the educational research literature on the self-efficacy beliefs of teachers regarding the teaching of scientific inquiry. However, the findings of this study must be interpreted with consideration of its limitations. One major limitation of this study was the small sample size, which was based on where I had access to participants. This study should be conducted on a larger sample size of scientific inquiry students because more participants make a study more reliable (Andrade, 2020; Borg & Gall, 1989).

This study was conducted on three sections of Scientific Inquiry during one semester at University A. The sample size was 74 for students who completed the pre-test survey and the sample size was 66 for students who completed the post-test survey. The sample size is enough to produce credible findings, however an increase in the sample size could possibly be helpful in future studies in an effort to increase the generalizability of this research. The research could be replicated with more participants. Furthermore, the sample size was restricted to one four-year university and represented a student body that is traditionally aged. It could be worthwhile to conduct research at other universities and community colleges and on a more diverse student body which may provide further insight.

Another limitation may be the uneven balance of the participants in the study. This study examined a population of participants that had far more females than males. There were 45 female participants and 29 male participants. A more evenly balanced population of participants may contribute to the improvement and reliability of the study. This study provides useful data however, further research could be conducted on a population that is more evenly balanced and larger in order to make the results more generalizable.

Additionally, this research had time restraints; because the course focuses on preservice teachers, the time required to conduct a follow up with observations of the participants in their future classrooms is prohibitive. Being able to follow up with participants would allow me to further determine whether the participants did, in fact, implement scientific inquiry into their classroom. Thus, these future observations could lead to more informed research results.

Another limitation of this study is a question about whether social desirability bias lowers the validity of the data obtained by TSI Instrument. Social desirability bias involves the tendency of people to admit or choose socially desirable traits and deny socially undesirable ones (Bergen & Labonté, 2020; Grimm, 2010). For the TSI Instrument, this would involve the tendency of students to choose answers related to more favorable traits regarding scientific inquiry over more unfavorable ones. Students may indicate that they agree with certain TSI Instrument questions because they believe those to be traits that are desirable for teachers to have or that the researchers would be looking for.

Social desirability bias can also lead to an overestimation of positive responses thus diminishing the accurateness of the consensus (Bergen & Labonté, 2020; Grimm, 2010). Students may choose answers that would seem right rather than reflect what they truly believe. To account for this bias, future research could consider using additional data collection and assessments that lessen the pressure to answer in a certain manner such as self-administered questionnaires. Follow-up interviews and classroom observations with students could help probe and clarify responses to determine whether the intention of their survey answers align with their actual behavior. Follow-up interviews with students once they have become actual classroom teachers could also help determine if their responses to the TSI Instrument correspond to their actual classroom teaching. It would also be beneficial to find ways to further detect and limit social desirability bias in this study since it is often cited in various ways in research in general (Bergen & Labonté, 2020).

Implications

Implications for Research

There are several implications for research that exist in this study. Because teachers are leaders for their classrooms, they are an important area of research regarding the implementation of scientific inquiry. Research shows that self-efficacy beliefs are much more malleable in the beginning of a teaching career than they are for students and teachers with more experience (Pendergast, et al., 2011; Tschannen-Moran & Woolfolk-Hoy, 2007). Bandura (1997) asserted that self-efficacy beliefs become resistant to change or reconsideration once they have been established. Thus, an implication for research warranting further investigation would be factors that affect the self-efficacy beliefs of students and how they are established. The course, Scientific Inquiry, can provide students with experience with scientific inquiry but changes in established self-efficacy beliefs of more experienced students may be more difficult. If self-efficacy beliefs are more malleable early, it would be beneficial to focus on inexperienced students rather than more experienced ones. Additionally, it would be beneficial to examine how to get experienced students, and even teachers already in practice, to change or reconsider their current beliefs.

Another implication for research warranting further investigation is based on the fact that the TSI Instrument relies on a Likert-scale numeric answer to questions. Future researchers may benefit from using other forms of data collection along with the TSI Instrument to more accurately assess student responses. Information gathered from interviews and observations may be a good way to further understand information gathered from a Likert scale instrument. Therefore, interviews and observations with participating students could be included with the TSI Instrument data collection technique to find any correlation between responses on the TSI Instrument and intent to use scientific inquiry-based instruction in the classroom.

It may also be beneficial to have follow up interviews and observations with these students as they enter their own future classrooms. Interviews with students who have become classroom teachers could help researchers determine if their responses to the TSI Instrument correspond to their current classroom teaching methods. They could also help researchers determine if their responses to the TSI Instrument correspond to the actual meaning of the TSI Instrument items.

Observations of these students as they enter their own future classrooms may also be able to show whether or not the scores from the TSI Instrument link to their current classroom behavior. Researchers would benefit from multiple observations because it is difficult to assess whether or not or how often teachers are utilizing inquiry from one observation. A scientific inquiry-based classroom is in some sense a culture and researchers may only observe some of its elements on any one given day. One observation may not give the most accurate portrayal of a classroom implementing scientific inquiry (Drayton & Falk, 2001). Thus, multiple follow up observations would be ideal.

The research presented and thoroughly supported in this paper has discussed the benefits associated with a higher sense of teacher self-efficacy such as student achievement (Ashton & Webb, 1986; Gibson & Dembo, 1984; Zee & Kooman, 2016)), time spent teaching science (Riggs & Jesunathadas, 1993), and the teaching of science as inquiry (Smolleck, Zembal-Saul, & Yoder, 2006). However, Wheatley (2002) suggests potential benefits related to the opposite, teacher doubts, which may be associated with lower self-efficacy. Teacher doubts may foster teacher reflection and growth, lead teachers to better classroom management, support teacher motivation to learn, and promote progressive reform policy. He asserts that high self-efficacy beliefs can actually obstruct educational reform. Thus, an examination of these conflicting views regarding teacher self-efficacy is another implication for research warranting further investigation.

According to Burke (2011), leadership during times of change has more to do with the person than their position within an organization. Additionally, it is important to involve all participants in a change effort rather than simply impose it (Burke, 2011).

Involving parents as a support system to scientific inquiry practices used in classrooms can help develop and foster student scientific inquiry skills. For example, parents could be encouraged to help focus less on providing answers to their child's work and more on inquiry practices such as comparing, predicting, evaluating, and concluding with activities such as games, shopping, visiting museums, and cooking. (Chichekian & Shore, 2016; Gelman & Brenneman, 2012; Vandermaas et al., 2018). Educational leaders could work with their students' parents and families to co-construct knowledge and activities that support in-school scientific inquiry practices as a means to advance scientific inquiry implementation efforts. Further, research indicates that parental involvement and support with scientific inquiry implementation efforts can be helpful to student learning (Niklas, et al., 2016; Vandermaas et al., 2018). Thus, another area possibly worthy of research is parental involvement regarding the implementation of scientific inquiry.

Implications for Practice

Current research and reform efforts in science education discuss and promote the advantages and benefits of scientific inquiry-based teaching and learning (Feng & McComas, 2015; Schmidt et al., 2002; Shymansky, 1984; Uno, 1990; Von Secker, 2002; Von Secker & Lissitz, 1999; Wells, 1995). Engaging preservice teachers in scientific inquiry opportunities including hands-on activities, modeling, and support helps to develop their understanding of scientific inquiry leading to more positive attitudes and higher self-efficacy regarding scientific inquiry (Charalambous & Philippou, 2010; Chichekian & Shore, 2016; Liang & Richardson, 2009). Support and guidance with scientific inquiry may be able to alter the self-efficacy beliefs of its participants (Chichekian & Shore, 2016; Richardson & Liang, 2008). Thus, it may be important for current elementary, high school, and college educators to restructure their teaching lessons to incorporate more scientific inquiry-based teaching and learning experiences into their curriculum so their students feel more comfortable with scientific inquiry in general and in their own classrooms. This would require these educators to offer lessons that focus less on doing traditional or cook-book labs in favor of scientific inquiry-based lessons. It is in this capacity that scientific inquiry teaching can be shown as a model to students and the teachers can be used as scientific inquiry mentors (Smith & Ingersoll, 2004).

Mentoring and support can be influential in preservice teacher experiences but can be valuable for teachers already in practice as well (Chichekian & Shore, 2016; Smith & Ingersoll, 2004). In fact, teachers who were provided with strong peer teachers were more tempted to change pre-existing frameworks, were less likely to rely on safe activities where they felt more in control and were more likely to try new methods of teaching (Chichekian & Shore, 2016). Support from colleagues and administrators can influence the amount of scientific inquiry utilized. For example, the support from a cooperating teacher was found to be very important in a student's ability to teach scientific inquiry (Smolleck & Mongan, 2011). Mentoring and support that provides experience and exposure to scientific inquiry classrooms where skilled teachers model scientific inquiry methods should be viewed as a critical element in teacher preparation programs and classes such as Scientific Inquiry. These experiences and exposure to scientific inquiry classrooms can help foster feelings of confidence in helping future teachers find the value of an inquiry-based instruction. Thus, offering mentors and support to practicing teachers may be a worthwhile way to increase the use of scientific inquiry in classrooms.

Bandura's (1977) social learning theory supports the idea that teachers who complete a program that provides an opportunity to experience scientific inquiry will have higher self-efficacy beliefs in turn making them feel more comfortable implementing scientific inquiry in their classrooms. Teachers should therefore be encouraged to attend professional development programs and workshops geared toward implementing scientific inquiry in the classroom. These courses, programs, and workshops allow students and teachers to experience inquiry-based instruction, which could increase their self-efficacy regarding teaching scientific inquiry (Avery, Trautmann, & Krasny, 2003; Chichekian & Shore, 2016; Knox, McDonnough, McKelvey, Baski, & Lewis, 2004; Liang & Richardson, 2009; Moynihan, & Markowitz, 2003). This could help increase the current low priority level of scientific inquiry in today's classrooms.

Bandura's (1997) research that suggests self-efficacy beliefs are likely to be lower for teachers who rely on a lot of support. He suggests that this is especially true for students at the beginning of their teaching career. Thus, any experience or program provided, such as the course, Scientific Inquiry, has to be aware and careful of the amount and kind of support offered so students do not learn to rely too much on this support. While support and teaching resources during the first years of teaching are critical for the development of overall teacher efficacy (Tschannen-Moran & Woolfolk-Hoy, 2002), students could become too accustomed to relying on others to suggest scientific inquiry aspects of the course such as topic selection, question development, and evaluation assistance. This could be problematic when the student is eventually on their own. Rather, students would benefit from the encouragement and experience of Scientific Inquiry teachers and programs that helped them develop their own scientific inquiry lessons. Finding a balance between offering critical support while nurturing independence is an area that will need to be further examined.

Using reflective practice may also help to encourage teachers to improve their practice regarding the teaching of science as inquiry (York-Barr, Sommers, Ghere, & Montie, 2006). Reflective practice focuses on how we are actually thinking and acting and less on our espoused theories which suggest what we think and say we do. Espoused theories relate to the beliefs we acquire through personal experiences, professional development, and education (Argyris & Schon, 1974). For example, we may use buzzwords and espouse that we use new theories learned in class or at professional development workshops. We can possibly even articulate these new ideas but that does not mean that we are necessarily implementing them or changing behaviors (Osterman & Kottkamp, 2004). Teachers may actually be performing in contradictory ways in everyday practice because espoused theories do not often guide our behaviors and actions (Argyris & Schon, 1974).

It is actually theories-in-use that directly and consistently influence what we do. Theories-in-use are beliefs and behaviors that guide and influence our practice much like we are on autopilot and are so deeply ingrained in us that we may be no longer aware of them (Osterman & Kottkamp, 2004). Reflective practice can help teachers gain new and deeper insights into what they are actually doing which can lead to behaviors aimed at improving their own teaching to overall benefit students (York-Barr, Sommers, Ghere, &

Montie, 2006). Because reflective practice can influence our actions, it is important that we use reflective practice to determine our theories-in-use so we can make changes in behaviors to ultimately improve our teaching practice. For example, a teacher who reflects on a lesson may realize that their espoused theory is incompatible with the actual behavior they exhibited while teaching the lesson. They may think they were acting in a way that promotes scientific inquiry but realize they actually were not. Teachers can use this self-awareness gained through reflective practice to teach the lesson more effectively the next time.

The goal of reflective practice is to make meaningful change by exploring and uncovering the beliefs that lead us to act in ineffective ways and is critical to understanding and eventually modifying our behaviors or theories-in-use (Osterman & Kottkamp, 2004). Understanding our actions is a critical element that provides an opportunity for making changes in our teaching practice (York-Barr, Sommers, Ghere, & Montie, 2006). Thus, it is important that we begin to consider and become more self-aware about our behaviors in the classroom, especially because they are not necessarily the ones we might choose if we really thought about it (Osterman & Kottkamp, 2004).

Thus, reflective practice could provide a means for improving our practice. For example, when I teach a lesson in class, it would be worthwhile to attempt to determine the thoughts that influenced my actions. In other words, I will think about why I did what I did rather than just considering the lesson accomplished and moving on to the next one. Incorporating reflective practice could help teachers to improve their practice, lead to enhanced student learning, and make meaningful change regarding the implementation of scientific inquiry.

In my own classroom, it would be prudent to not only model and teach scientific inquiry as a concept but to check in on and build the confidence of my students regarding their ability to teach scientific inquiry. Substantial research surrounds the concept that higher self-efficacy regarding scientific inquiry leads to its implementation (Bhattacharyya et al., 2009; McKeown et. al., 2016; Smolleck et al., 2006). Thus, fostering ideas in my classroom would be a worthwhile endeavor. Taking students to see scientific inquiry in real classrooms and having guest speakers in my class could help ensure that the course is offering ample support to drive home the importance of scientific inquiry so students see its value and learn methods of confident implementation.

Bandura's (1977) social learning theory supports the notion that teachers who have successful mastery experiences with scientific inquiry are more likely use it in their classrooms. He asserted that self-efficacy may be increased through use of experience as well as modeling. Further, all current reform documents include scientific inquiry as a staple in today's classrooms (NRC, 2000). Thus, promoting and offering experience with scientific inquiry for students may be beneficial in an attempt to get them to teach it in their future classrooms.

Offering high school classes and college courses regarding scientific inquiry-based instruction would be key in an attempt to increase its usage (Smolleck & Nordgren, 2014). Similarly, current teachers could benefit from classes, courses, workshops, in-service training and professional development programs, aimed at providing modeling and experience with scientific inquiry that display how scientific inquiry teaching and learning is actually conducted. In order for scientific inquiry to be implemented, teachers need to learn the meaning of scientific inquiry, as well as its value, and how it is used to help students learn (NRC, 2012). This is particularly important based on the data from this study which indicates that students who take a course such as Scientific Inquiry may have an increase in their self-efficacy scores regarding the teaching of scientific inquiry which could lead to its implementation in their future classrooms.

Lack of experience with scientific inquiry may be a viable reason why it remains a low priority in today's classrooms (Chichekian & Shore, 2016; Damnjanovic, 1999). Thus, educational leaders must offer students and teachers opportunities that provide experience with scientific inquiry to increase teachers' self-efficacy or the belief in their ability to teach (Chichekian & Shore, 2016; Palmer, 2006; Richardson & Liang, 2008). These types of opportunities and experiences can help lead to positive changes in beliefs regarding the teaching of scientific inquiry (Avery, Trautmann, & Krasny, 2003; Knox, Moynihan, & Markowitz, 2003) which may lead our teachers to utilize scientific inquiry in their classrooms. Teacher preparation programs must be held accountable regarding the potential impact they have on future teachers' practices and confidence with practices regarding inquiry teaching and learning.

Implications for Leadership

Leadership can occur through anyone at any level (Bass & Riggio, 2006). Teachers are educational leaders and role models to their students just as much as principals and superintendents (Lumpkin, 2008). They lead students all day through modeling behavior and by being examples and influencers in the way they speak and behave (Nadelson, Booher, & Turley, 2020). They specifically lead and influence the morality, work ethic, and character of the students in their classrooms on a daily basis

(Lumpkin, 2008). They lead their students in their classrooms as well as outside of their classrooms through various activities, programs, and events. Teachers must view themselves as leaders in order to effectively navigate the challenges associated with learning and student success (Nadelson, Booher, & Turley, 2020).

All educational leaders should design, enforce, and mandate policy that encourages school districts, its administrators, and its teachers to participate in workshops, in-service training, and professional development programs that promote the use of scientific inquiry-based teaching. Teachers are able to challenge and change their pre-existing frameworks when provided with these kinds of opportunities (Chichekian & Shore, 2016). Brand and Moore (2011) noticed changes in teacher instruction after implementing scientific inquiry professional development workshops. Researchers noted that teachers began introducing ideas with questions and provided more opportunities for student discussions. These practices align with inquiry models of learning and teaching (Chichekian & Shore, 2016).

Consistent and perseverant efforts tend to help produce changes in self-efficacy (Chichekian & Shore, 2016). Thus, long-term professional development should be offered rather than one-time workshops in an attempt to alter the self-efficacy beliefs of teachers, particularly if they show hesitance toward a commitment to change. Educational leaders may have to support a sustained and extended level of commitment when supporting inquiry implementation efforts. This will ensure that teachers have ample time to gain the confidence necessary for real change regarding the implementation of scientific inquiry.

This level of commitment could include requiring teachers to continually observe successful scientific inquiry being modeled and providing teachers with opportunities to experience doing inquiry themselves. Sending teachers to multiple scientific inquiry-based workshops throughout the course of their teaching career could also be helpful in continuing its implementation and continued utilization in classrooms. Transformational leadership which provides a clear vision and marked passion of goals along with the ability to authentically inspire others could help encourage and motivate teachers to commit to this vision Transformational leaders could inspire teachers to achieve remarkable results because they are not just encouraged to participate but rather inspired to become leaders themselves (Bass & Riggio, 2006). This leadership style could help foster an extended level of commitment which could have a trickle-down effect where students are being exposed to and inspired by scientific inquiry teachers in elementary, middle, and high school, and college, increasing the overall implementation of scientific inquiry as a teaching and learning method and making it a higher priority in science classrooms.

Lee and Houseal (2003) noted a correlation between low self-efficacy beliefs and a tendency for teachers to use authoritative methods of teaching. This leadership style tends to rely on teaching methods such as giving directions to students, setting goals for them, and structuring their work. They do not encourage communication among group members (Northouse, 2012; Wren, 1995). The authoritarian leader provides direction and retains complete control of students. These methods rely on teacher-centered activities which may include textbook instruction and individual work rather than student-centered activities such as hands-on work and group work related to scientific inquiry-based instruction.

Lee and Houseal (2003) also found a correlation between high self-efficacy beliefs and a tendency to use less authoritative methods of teaching in favor of methods of teaching that are less-directive and more student-centered (Marshall et al., 2007). These methods of teaching align with a democratic leader or teacher who assists students by providing information and offering guidance and suggestions without giving orders or applying pressure. They treat students as fully capable of doing their own work and see themselves as guides rather than as directors and encourage communication between students (Northouse, 2012). Student ideas and suggestions are regarded as equally important as the teacher's contributions. It is important for policy makers and educational leaders to foster learning environments that defer from imposing ideas onto students but rather allow students the opportunity to invent and creatively suggest their own ideas for learning. In a scientific inquiry class, it is much more educationally advantageous to allow children to be active participants in their own learning experiences. Rather than providing explicit instructions, teachers must give students the needed materials and then offer ideas and suggestions to set them on their own path to discovery.

Lee and Houseal (2003) suggest that beliefs have a direct connection to practice and that teachers must stray from authoritative methods of teaching in order to allow for activities such as scientific inquiry instruction. Much like scientific inquiry investigations, which may be less efficient than other methods of teaching, democratic methods of teaching may take extra time and commitment on the part of the teacher. The work will get accomplished but perhaps not as quickly as if an authoritarian method was utilized (Northouse, 2012). Democratic teaching methods and scientific inquiry may require more time in order to allow students to be involved and creative. Based on the documented benefits associated with these teaching methods, the outcome may be well worth the effort students who use scientific inquiry in their classroom to learn are using the methods found to be the most effective for learning for understanding (NRC, 2000). Thus, teachers seeking higher student achievement must be encouraged to utilize the scientific inquiry approach.

Incorporating the components of emotional intelligence may be an area worth investigating in terms of increasing the use of scientific inquiry. Goleman (2004) discusses five major components of emotional intelligence: self-awareness, self-regulation, motivation, empathy, and social skill. These components have been shown to drive the performance of school leaders making them more effective in their roles and more equipped to deal with important problems such as addressing the lack of scientific inquiry in today's classrooms. Thus, they are important avenues to explore regarding the implementation of scientific inquiry by educational leaders in schools.

Research shows that as emotional intelligence rises, an increase in overall performance also rises (Bharwaney, et al., 2007). Because we are able to identify the crucial relationship between emotional intelligence and performance, every school leader should be trying to do whatever it takes to raise their emotional intelligence in order to perform most effectively. Because emotional state drives performance (Goleman, et al., 2001), school leaders should increase or be shown how to heighten their levels of emotional intelligence to be sure that they are performing to the best of their ability regarding the implementation of scientific inquiry. Therefore, it may be wise to ascertain how increasing the emotional intelligence of school leaders may be able to help increase the use of scientific inquiry.

Conclusion

Educational leaders can encourage the implementation of scientific inquiry by requiring teachers to participate in workshops, in-service training, and professional development programs aimed at promoting scientific inquiry-based instruction, more effective teaching styles, and emotional intelligence. These opportunities could include hands-on activities, modeling, guidance, and support aimed to encourage their understanding of scientific inquiry which can change their self-efficacy beliefs (Chichekian & Shore, 2016; Richardson & Liang, 2008). Policymakers and educational leaders must also be held responsible for upholding policies that currently exist regarding the implementation of scientific inquiry and for offering opportunities such as classes, courses, workshops, in-service training and professional development programs that could help reach the worthwhile goal of creating scientifically literate students and teachers. Therefore, in an effort to develop scientifically literate students who are equipped to participate in today's crucial issues involving science and technology as well as in compliance with current reform efforts, policymakers and educational leaders must be responsible for offering students and teachers these critical experiences with scientific inquiry.

This is a particularly compelling policy and educational issue given the current dismal ranking of US students compared to many other industrialized nations in science assessments (Desilver, 2017). The implementation of scientific inquiry in today's classrooms may be a challenging issue but it is a critical one for our nation (Roehrig & Luft, 2004). Based on Bandura's social learning theory (1977), teachers must feel confident in their abilities to teach science as inquiry if science education reform is going to happen in our schools (Smolleck & Nordgren, 2014). Teachers who engage in scientific inquiry-based learning have an increased efficacy or belief in their ability to teach science (Haim, 2003; Palmer, 2006; Liang & Richardson, 2009). Science education reform will not advance without focusing on science teacher reform. Thus, further research regarding the self-efficacy beliefs which have been shown to influence teaching must be investigated.

Overall, the results of this study are encouraging toward the goal of implementing scientific inquiry in today's classrooms. In an ideal setting, students would possess high self-efficacy levels regarding the teaching of scientific inquiry due to opportunities to have positive experiences with it. In order for students to possess high self-efficacy levels, policy makers and administrators must make these opportunities accessible to future and current teachers (Chichekian & Shore, 2016; DiBiase & McDonald, 2015; Haim, 2003; Kleine et al., 2002; McKeown et al., 2016; Oleson & Hora, 2014; Windschitl, 2002). In turn, these teachers would have the self-efficacy needed to use and therefore model scientific inquiry which would influence their own students.

In my own classroom, I tend to employ democratic leadership which allows students to be active participants capable of structuring much of their own work (Marshall et al., 2007). This type of leadership in the course, Scientific Inquiry, not only allows students to observe successful scientific inquiry investigations modeled, but also allows them to perform and be successful with their own investigations. I also tend to employ transformational leadership aimed to authentically inspire, encourage and motivate students to become active participants and leaders regarding the development and utilization of scientific inquiry in science classrooms (Bass & Riggio, 2006).. This is accomplished through empowering educational opportunities and learning experiences, proper guidance, and mentoring with scientific inquiry.

According to the data collected for this study, participating in the course, Scientific Inquiry, increases student self-efficacy regarding scientific inquiry and may help change the course of our nation's scientific education for the better. It is imperative that teacher preparation programs, professional development programs, and classrooms emphasize and model scientific inquiry. These experiences that help increase self-efficacy toward scientific inquiry will lead to better science teaching that meets state and national mandates and, more importantly, produces more scientifically literate students and teachers.

References

ACT. (2016). The condition of college and career readiness 2016. Iowa City, IA.

Alberts, B. (2009. Restoring Science to Science Education. *Issues in Science & Technology. 25*(4), 77-80.

Allinder, R.M. (1995). An examination of the relationship between teacher efficacy and curriculum-based measurement and student achievement. Remedial and Special Education, 16, 247-254.

American Association for the Advancement of Science. (1993). *Benchmarks for science literacy.* New York, NY: Oxford University Press.

Amrita et al. (2014). Importance of Science in School Curriculum. *The National Journal*. *72*. Modern Rohini Education Society (Regd.).

Anderson, O. (1997). A neurocognitive perspective on current learning theory and science instructional strategies. *Science Education, 81*, 67-89.

Andrade, C. (2020). Sample size and its importance in research. *Indian Journal of Psychological Medicine*. *42*(1), 102-103.

Argyris, C., & Schon, D. D. (1974). *Theory in practice: Increasing professional effectiveness*. San Francisco, CA: Jossey Bass.

Avery, L., Trautmann, N., & Krasny, M. (2003, March). *Impacts of participation in a GK-12 fellowship program on teachers' conceptions and use of inquiry science.* Paper presented at the annual meeting of the National Association for Research in Science Teaching: Philadelphia, PA.

Backus, L. (2005). A year without procedures. *The Science Teacher, 72*, 54-58.

Bandura, A., (1969). *Principles of behavior modification.* New York: Holt, Rhinehart & Winston.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of Behavioral change. *Psychological Review, 84*(2), 191–215.

Bandura, A., (1981). Self-referent thought: A developmental analysis of self- efficacy. In J.H. Flavell & L. Ross (Eds.). *Social cognitive development frontiers and possible futures.* Melbourne, Australia: Cambridge.

Bandura, A. (1982). Self-efficacy mechanism in human agency. American Psychologist, *37*(2), 122–147.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice-Hall.

Bandura, A. (1989). Regulation of cognitive processes through perceived self-efficacy. *Developmental Psychology, 25*(5), 729–735.

Bandura, A. (1995). *Self-efficacy in changing societies*. Melbourne, Australia: Cambridge University Press.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York. W.H. Freeman.

Banchi, H., & Bell, R. (2008). The Many Levels of Inquiry. *Science and Children*, *46(*2), 26–29.

Banilower, E. R., Smith, P. S., Weiss, I. R., Malzahn, K. A., Campbell, K. M., & Weis, A. M. (2013). *Report of the 2012 National Survey of Science and Mathematics Education.* Chapel Hill, NC: Horizon Research, Inc.

Barab, S., & Dede, C. (2007). Games and immersive participatory simulations for science education: An emerging type of curricula. *Journal of Science Education and Technology. 16*, 1-3.

Bass, B. M., & Riggio, R. E. (2006). *Transformational Leadership*. Mahwah, NJ: Lawrence Erlbaum Associates.

Beede, D., Julian, T., Langdon, D., McKittrick, G., Khan, B., & Doms, M. (2011). Women in STEM: A gender gap to innovation. *Economics and Statistics Administration Issue Brief*, 4–11.

Bell, R. (2005). Simplifying inquiry instruction. *The Science Teacher*, 30-33.

Bergen, & Labonté, R. (2020). "Everything Is Perfect, and We Have No Problems": Detecting and Limiting Social Desirability Bias in Qualitative Research. *Qualitative Health Research*, *30*(5), 783–792.

Beshears, C. M. (2012). *Inquiry-based instruction in the social studies: Successes and challenges*. University of Arkansas.

Bharwaney G., Bar-On, R., and MacKinlay, A. (2007). *EQ and the Bottom Line: Emotional Intelligence Increases Individual Occupational Performance, Leadership and Organizational Productivity.* Ampthill, United Kingdom.

Bhattacharyya, S., Volk, T., & Lumpe, A. (2009). The influence of an extensive inquiry-based field experience on pre-service elementary student teachers' science teaching beliefs. *Journal of Science Teacher Education*, *20*, 199-218.

Boyd, E., & George, K. D. (1973). The effect of science inquiry on the abstract categorization behavior of deaf children. *Journal of Research in Science Teaching, 10*, 91-99.

Brand, B. R., & Wilkins, J. L. M. (2007). Using self-efficacy as a construct for evaluating science and mathematics methods courses. *Journal of Science Teacher Education, 18*, 297-317.

Bruce, C.D., Esmonde, I., Ross, J., Dookie, L., & Beatty, R. (2010). The effects of sustained classroom-embedded teacher professional learning on teacher efficacy and related student achievement. *Teaching and Teacher Education*, 26(8), 1598 1608.

Burke, W. W. (2011). Organization Change: Theory and practice. (4th edition). Thousand Oaks, 3 CA: Sage Publications.

Bybee R., & Scotter P. (2007). Reinventing the science curriculum: Science in the spotlight. *Educational Leadership*, *64*(4), 43-47.

Capps, D.K., Crawford, B.A., & Constas, M.A. (2012). A review of the empirical literature on inquiry professional development: Alignment with best practices and a critique of the findings. *Journal of Science Teacher Education*, 23(3), 291-318.

Capps, D. K., & Crawford, B. A. (2013). Inquiry-based professional development: What does it take to support teachers in learning about inquiry and nature of science? *International Journal of Science Education*, *35*(12),1947-1978.

Capps, D. K., Shemwell, J. T., & Young, A. M. (2016). Over reported and misunderstood? A study of teachers' reported enactment and knowledge of inquiry-based science teaching. *International Journal of Science Education, 38*(6), 934–959.

Carey, S. (1985). *Conceptual change in childhood.* Cambridge, MA: MIT Press.

Cetin, P.S., (2021). Effectiveness of inquiry-based laboratory instruction on developing secondary students' views on scientific inquiry. *Journal of Chemical Education*. *98*(3), 756-762.

Charalambous, C.Y., & Philippou, G.N. (2010). Teachers' concerns and efficacy beliefs about implementing a mathematics curriculum reform: integrating two lines of inquiry. *Educational Studies in Mathematics.* 75, 1–21.

Chatterjee, S., & Hadi, A. S. (2012). *Regression Analysis by Example*. John Wiley & Sons, Incorporated.

Chichekian T., & Shore, B.M. (2016). *Preservice and practicing teachers' self-efficacy for inquiry-based instruction*. Cogent Education. *3*(1).

Cigdemoglu, C., & Köseoğlu, F. (2019). Improving Science Teachers' Views about Scientific Inquiry: Reflections from a Professional Development Program Aiming to Advance Science Centre-School Curricula Integration. *Science & Education*, *28*(3), 439–469.

Corder, & Foreman, D. I. (2014). *Nonparametric Statistics: A step-by-step approach* (Second edition.). Wiley.

Czerniak, C.M., & Schriver, M. (1994). An examination of preservice science teachers' Beliefs and behaviors as related to self-efficacy. *Journal of Science Teacher Education*, *5*(3), 77-86.

Damnjanovic, A. (1999). Attitudes in inquiry-based teaching: Differences between preservice an inservice teachers. *School Science and Mathematics , 99*, 71-76.

Drayton, B., & Falk, J. (2000). Hands on! Hands-on math and science learning. *TERC, 23*(2), 1-24.

Das, N., Singh, A., & Amrita. (2014). Importance of science education in school curriculum. *We School Knowledge Builder-The National Journal*. *2*(4), 15-18.

DeSilver, D. (2017). US students' academic achievement still lags that of their peers in many other countries. PEW Research Center.

DiBiase, W., & McDonald, J. (2015) Science teacher attitudes toward inquiry-based teaching and learning. *The Clearing House: A Journal of Educational Strategies*, *Issues and Ideas*, 88(2), 29-38.

Dorph, R., Goldstein, D., Lee, S., Lepori, K., Schneider, S., & Venkatesan, S. (2007). *The status of science education in the Bay Area: Research brief.* Berkeley, CA: University of California.

Dow, P. (1999). *Why Inquiry? A Historical and Philosophical Commentary*, Foundations, Vol 2, National Science Foundation.

Drayton, B., & Falk, J. (2001). Tell-tale signs of the inquiry-oriented classroom. *NASSP Bulletin, 85* (623), 24-34.

Eagan MK, Stolzenber EB, Berdan Lozano J, Aragon MC, Suchard MR, Hurtado S. (2014). Undergraduate teaching faculty: The 2013–2014 HERI faculty survey. *Higher Education Research Institute*, University of California.

Enochs, L. G., Scharmann, L. C., & Riggs, I. M. (1995). The relationship of pupil control to preservice elementary science teacher self-efficacy and outcome expectancy. *Science Education, 79*(1), 63–75.

Feng. J. & McComas, W. F. (2015). The Effects of Inquiry Teaching on Student Science Achievement and Attitudes: Evidence from Propensity Score Analysis of PISA Data. *International Journal of Science Education*, 37(3), 554-576.

Fishman, B.J., Marx, R.W., Best, S., Tal, R.T. (2003). Linking teacher and student learning to improve professional development in systemic reform. Teaching and Teacher Education, 19, 643-658.

Freedman, M. P. (1997). Relationship among laboratory instruction, attitude toward science, and achievement in science knowledge. *Journal of Research in Science Teaching, 34*, 343-357.

Freeman, S., Eddy, S.L., McDonough, M., Smith, M.K., Okoroafor, N., Jordt. H., Wenderoth, M.P. (2014). End of lecture: Active learning increases student performance across the STEM disciplines. Proceedings of the National Academy of Sciences of the United States of America. *111(*23). 8410–8415.

Funk, C., & Parker, K. (2018). *Women and men in STEM often at odds over workplace equity*. Washington, DC: Pew Research Center.

Fusaro, M., & Smith, M. C. (2018). Preschoolers' inquisitiveness and science-relevant problem solving. *Early Childhood Research Quarterly, 42,* 119–127.

Geier, R., Blumenfeld, P.C., Marx, R.W., Krajcik, J.S., Fishman, B., Soloway, E., & Clay-Chamber, J. (2008). Standardized test outcomes for students engaged in inquiry-based science curricula in the context of urban reform. *Journal of Research in Science Teaching*, 45, 922-939.

Goleman, D., Boyatzis, R. & McKee, A. (2001). Primal leadership: The hidden driver of great performance. *Breakthrough Leadership.* (PDF)

Goleman, D. (2004). What makes a leader? *Harvard Business Review,* Vol 82, No. 1, p. 82 - 91. (PDF)

Graziano, A.M.& Raulin, M.L. (2000) *Research Methods: A process of inquiry fourth edition.* Needham Heights, Massachusetts: Allyn & Bacon.

Gribbons, B. & Herman, J. (1996). True and quasi-experimental designs. *Practical Assessment, Research, and Evaluation*: *5*(14).

Grimm, P. (2010). Social desirability bias. In Sheth, J., Malhotra, N. (Eds.), Wiley international encyclopedia of marketing.

Haim, E. (2003). Inquiry-Events as a Tool for Changing Science Teaching Efficacy Belief of Kindergarten and Elementary School Teachers. *Journal of Science Education and Technology*, 12, (4), 495-501.

Hatch, J. (2018). "Better teachers are needed to improve science education," Nature, vol. 562(7725), pages 2-4, October.

Hofer, E & Lembens, A. (2019). Putting inquiry-based learning into practice: How teachers changed their beliefs and attitudes through a professional development program. *Chemistry Teacher International*, *1*(2).

Holzberger, D., Philipp, A., & Kunter, M. (2013). How teachers' self-efficacy is related to instructional quality: A longitudinal analysis. *Journal of Educational Psychology*, 105, 774–786.

Huangfu, W. (2012). Effects of EFL teachers' self-efficacy on motivational teaching behaviors. *Asian Social Science*, *8*(15), 68.

Hurd, P. D., Bybee, R. W., Kahle, J. B., & Yager, R. E. (1980). Biology education in secondary schools of the united states. *The American Biology Teacher, 42* (7), 388-410.

Isaac, S. & Michael, W.B. (1997). *Handbook of research and evaluation*. San Diego, CA: Educational and Industrial Testing Services.

Johnson, C. C. (2006). Effective professional development and change in practice: Barriers teachers encounter and implications for reform. *School Science and Mathematics, 106*, 1-12.

Khanshan, S.K., Yousefi, M.H. (2020). The relationship between self-efficacy and instructional practice of in-service soft disciplines, hard disciplines and EFL teachers. *Asian. Journal of Second. Foreign Language. Educ.* **5,** 1.

Kleine, K., Brown, B., Harte, B., Hilson, A., Malone, D., Moller, K., et al. (2002). Examining inquiry. *Principal Leadership , 3* (3), 36-39.

Liang, L.L., Richardson, G.M. (2009). Enhancing prospective teachers' science teaching efficacy beliefs through scaffolded, student-directed inquiry. *Journal of Elementary Science Education.* 21, 51–66.

Llewellyn, D. (2001). *Inquire within: Implementing inquiry-based science standards.* Thousand Oaks, CA: Corwin Press.

Llewellyn, D. (2005). *Teaching high school science thorugh inquiry.* Thousand Oaks, CA: Corwin Press. Llewellyn, D. (2013). *Teaching high school science through inquiry and augmentation.* Thousand Oaks, CA: Corwin Press.

Lott, G. W. (1983). The effect of inquiry teaching and advance organizers upon student outcomes in science education. *Journal of Research in Science Teaching, 20*(5), 437-451.

Lott, K.H. (2011). FIRE UP the inquiry. Lose the routine, tweak your "cookbook lab," and reach a level of open inquiry with these strategies used during a unit on heat. *Science and Children*, *48*(7), 29-33.

Luft, J.A., & Roehrig, G.H. (2007). Capturing science teachers' epistemological beliefs: The development of the Teacher Beliefs Interview, *Journal of Science Education*, *11*(2), 38-63.

Marshall, J.C., Alston, D.M. (2014). Effective, Sustained Inquiry-Based Instruction Promotes Higher Science Proficiency Among All Groups: A 5-Year Analysis. *Science Teacher Education,* 25**,** 807-821 (2014).

Marshall, J. C., Horton, R., Igo, B. L., & Switzer, D. M. (2007). K-12 science and mathematics teachers' beliefs about and use of inquiry in the classroom. *International Journal of Science and Mathematics Education, 7*, 575-596.

Matyas, M. L. (2000). *Teaching and learning by inquiry.* Bethesda. MD: The American Physiological Society.

McBride, J. W., Bhatti, M. I., Hannan, M. A., Feinberg, M. (2004). Using an inquiry approach to teach science to secondary school science teachers. *Physics Education*, *39*(5), 1-6.

McComas, W. (2005). Laboratory instruction in the service of science teaching and learning. *The Science Teacher, 72*, 24-29.

McDonnough, J., McKelvey, S., Baski, A., & Lewis, D. (2004). Hands-on physical science for in-service teachers. *The Journal of Mathematics and Science*, 67-78.

McKeown, T.R., Abrams, L.M., Slattum, P.W., & Kirk, S.V. (2016). Enhancing teacher beliefs through an inquiry-based professional development program. *Journal of Education in Science, Environment and Health*, 2(1), 85- 97.

Medawar, P. (1984). *The limits of science.* Oxford, England: Oxford University Press.

Nadelson L.S., Booher L., & Turley M. (2020). Leaders in the Classroom: Using Teaching as a Context for Measuring Leader Identity. *Frontiers in Education.*

National Academy of Sciences. (1997). *Science for All Children: A Guide to Improving Elementary Science Education in Your School District. Washington, DC: The National Academies Press.*

National Center for Education Statistics. (2022). *Characteristics of Public School Teachers. Condition of Education*. U.S. Department of Education, Institute of Education Sciences.

National Commission on Excellence in Education. (1983). *A Nation at Risk: The Imperative for Educational Reform.* Washington, DC: Government Printing.

National Research Council. (2012). A framework for K-12 science education: Practices, crosscutting concepts, and core ideas. Washington, DC: The National Academies Press.

National Research Council. (1996). *National science education standards.* Washington, DC: National Academy Press.

National Research Council. (2000). *Inquiry and the national science education standards*. Washington, DC: National Academy Press.

National Science and Technology Council. (2013). Federal science, technology, engineering, and mathematics (STEM) education: 5-Year strategic plan. Washington, DC.

NGSS Lead States (2013). Next generation science standards: For states, by states. Washington, DC: The National Academies Press.

Northouse, Peter G. (2012). *Introduction to leadership concepts and practice*. 2nd edition. Thousand Oaks, CA: Sage Publications.

Oleson, A., & Hora, M. T. (2014). Teaching the way they were taught? Revisiting the sources of teaching knowledge and the role of prior experience in shaping faculty teaching practices. *Higher Education*, *68*(1), 29-45.

Osterman, Karen F., & Kottkamp, Robert B. (2004). *Reflective practice for educators: Professional development to improve student learning.* Thousand Oaks, CA: Corwin Press.

Pajares, M. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research, 62*, 307-332.

Pendergast, D., Garvis, S. & Keogh, J. (2011). Pre-service student-teacher self-efficacy beliefs: an insight into the making of teachers. *Australian Journal of Teacher Education*, 36(12), 46– 58.

Pyle, E. J. (2008). Inquiry in the earth sciences. In J. Luft, R. Bell, J. Gess-Newsome, & (Eds.), *Science as inquiry in the secondary setting* (pp. 31-40). Arlington, VA: NSTA press. Raloff, J. (1988). U.S. education failing in science? *Science News, 133* (11), 165-166.

Rayburn, A.M. (2009). Differences in females' math and science self-efficacy based on gender-type socialization and gender role type.

Richardson, G. & Liang, L, (2008). The use of inquiry in the development of preservice teacher efficacy in mathematics and science, *Journal of Elementary Science Education*. 20 (1), 1-16.

Riggs, I. M., & Enochs, L. G. (1990). Toward the development of an elementary teacher's science teaching efficacy belief instrument. *Science Education, 74*(6), 625–637.

Riggs, I. (1995, April). The characteristics of high and low efficacy elementary teachers. Paper presented at the annual meeting of the National Association for Research in Science Teaching, San Francisco.

Salkind, N. (2007). *Statistics for people who (think they) hate statistics.* Thousand Oaks, CA. Sage Publications.

Salter, I., & Atkins, L. J. (2013, February). Student-Generated Scientific Inquiry for Elementary Education Undergraduates: Course Development, Outcomes and Implications. *Journal of Science Teacher Education, 24*, 157-177.

Schmidt, P. R., Gillen, S., Teresa, C. Z., & Stone, R. (2002). Literacy learning and scientific inquiry: Children respond. *The Reading Teacher, 55*(6), 534-548.

Schwab, J. J. (1962). *The teaching of science: The teaching of science as enquiry.* Cambridge, MA: Harvard University Press.

Shepardson, D. P., & Leuenberger, T. J. (2008). Field studies as a pedagogical approach to inquiry. In J. Luft, R. Bell, J. Gess-Newsome, & (Eds.), *Science as inquiry in the secondary setting* (pp. 53-63). Arlington, VA: NSTA Press.

Shulene, J. A. (1972). *Inquiry oriented pictorial riddles in science for educable mentally handicapped children.* Unpublished doctoral dissertation, University of Northern Colorado: Greeley, CO.

Shymansky, J. (1984). BSCS programs: Just how effective were they? *The American Biology Teacher, 46*(1), 54-57.

Singer, S. R., Hilton, M. L., Schweingruber, H. A., & National Research Council. (2006). *America's lab report: Investigations in high school science*. Washington, DC: National Academies Press.

Singer, J., Marx, R. W., Krajcik, J., & Clay Cambers, J. (2000). Constructing extended inquiry projects: Curriculum materials, for science education reform. *Educational Psychologist, 35*, 165-178.

Smolleck, L., & Mongan, A. (2011). Changes in preservice teachers' self-efficacy: From science methods to student teaching. *Journal of Educational and Developmental Psychology*. *1*(1), 133-145.

Smolleck, L. A., & Nordgren, S. B. (2014). Transforming standards-based teaching: Embracing the teaching and learning of science as inquiry in elementary classrooms. *Journal of Education and Human Development*, *3*(2), 1–19.

Smolleck, L. D., Zembal-Saul, C., & Yoder, E. P. (2006). The development and validation of an instrument to measure preservice teachers' self-efficacy in regard to the teaching of science as inquiry. *Journal of Science Teacher Education, 17*, 137-163.

Sparks, S. (2021). The latest science scores are out. The news isn't good for schools. Education Week.

Tamir, P. (1983). Inquiry and the science teacher. *Science Education, 67*(5), 657-672.

Taylor, J & Bilbrey, J. (2012). Effectiveness of inquiry-based and teacher directed instruction in an Alabama elementary school. *Journal of Instructional Pedagogies*. *8*, 1-17.

Tschannen-Moran, M., & Woolfolk-Hoy, A. (2001). Teacher efficacy: Capturing an elusive construct. Teaching and Teacher Education, 17, 783-805.

Tschannen-Moran, M., & Woolfolk-Hoy, A. (2007). The differential antecedents of self-efficacy beliefs of novice and experienced teachers. *Teaching and Teacher Education, 23* (6), 944-956.

Tschannen-Moran, M. & Woolfolk-Hoy, A. (2002, April). *The influence of resources and support on teachers' efficacy beliefs.* Paper presented at the annual meeting of th American Educational Research Association: New Orleans, LA.

Tschannen-Moran, M., Woolfolk-Hoy, A.,& Hoy, W. K. (1998). Teacher efficacy: Its meaning and measure. *Review of Educational Research , 68* (2), 202-248.

Uno, G. E. (1990). Inquiry in the classroom. *BioScience, 40*(11), 841-843.

Van Klaveren, C. (2010) Lecturing style teaching and student performance. Working Papers 29. Top Institute for Evidence Based Education Research.

Von Secker, C. (2002). Effects of inquiry-based teacher practices on science excellence and equity. *The Journal of Educational Research , 95*, 151-160.

Von Secker, C., & Lissitz, R. (1999). Estimating the impact of instructional practices on student achievement in science. *Journal of Research in Science Teaching, 36*, 1110-1126.

Wallace, C.S., & Kang, N. (2004). An investigation of experienced secondary science teachers' beliefs about inquiry: An examination of competing belief sets. *Journal of Research in Science Teaching*, 41, 936-960.

Wells, G. (1995). Language and the inquiry-oriented curriculum. *Curriculum Inquiry, 25*, 233-269.

Wenning, C.J. (2005). Implementing inquiry-based instruction in the science classroom: A new model for solving the improvement-of-practice problem. *Journal of Physics Teacher Education Online*, *2*(*4*), 9.

Wenning, C. J. (2010). Experimental inquiry in introductory physics courses. *Journal of Physics Teacher Education Online*, *6*(*2*), 1-8.

Wilson, C., Taylor, J., Kowalski, S., & Carlson, J. (2009). The relative effects of inquiry-based and commonplace science teaching on students' knowledge, reasoning and argumentation: A randomized control trial. *Journal of Research in Science Teaching*. *47(3)*, 276-301.

Windschitl, M. (2002). Inquiry projects in science teacher education: What can investigative experience reveal about teacher thinking and eventual classroom practice? *Science Teacher Education, 87*, 112-143.

Wren, J.T. (1995). *The leader's companion*. New York: Free Press.

York-Barr, Sommers, Ghere, & Montie. (2006) *Reflective Practice to Improve Schools: An Action Guide for Educators,* Thousand Oaks, CA: Corwin Press.

Zee, M., & Koomen, H. M. Y. (2016). Teacher Self-Efficacy and Its Effects on Classroom Processes, Student Academic Adjustment, and Teacher Well-Being. Review of Educational Research, 86(4), 981–1015.

Zembal-Saul, C. (2009). Learning to teach elementary school science as argument. *Science Education*. *93*(4), 687-719.