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Relationship Between Teacher Inquiry Science Instruction Self-Efficacy and Student Achievement

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2016

Abstract

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by

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Doctoral Study Submitted in Partial Fulfillment
of the Requirements for the Degree of
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Abstract

Standardized test data indicate that student achievement in science is a problem both nationally and locally. At the study site, only a small percentage of fifth-grade students score at the advanced level on the Maryland state science assessment (MSA). In addition, the performance of African American, economically disadvantaged, and special education students is well below that of the general student population. Some studies have shown that teacher self-efficacy affects student achievement. Therefore, the purpose of this study was to explore the relationship between fifth-grade teacher inquiry science instruction self-efficacy scores and the scores of their students on the MSA. Bandura's work on the effect of self-efficacy on human behavior provided the theoretical basis for this study. The research questions examined the relationship between teacher inquiry science instructional self-efficacy scores and students' science MSA scores as well as the relationship by student subgroups. A correlational research design was used. The Teaching Science as Inquiry survey instrument was used to quantify teacher self-efficacy, and archival MSA data were the source for student scores. The study included data from 22 teachers and 1,625 of their students. A 2-tailed Pearson coefficient analysis revealed significant, positive relationships with regard to overall student achievement ($r_{20} = .724$, $p < .01$) and the achievement of each of the subgroups (African American: $r_{20} = .549$, $p < .01$; economically disadvantaged: $r_{20} = .655$, $p < .01$; and special education: $r_{18} = .532$, $p < .05$). The results of this study present an opportunity for positive social change because the local school system can provide professional development that may increase teacher inquiry science instruction self-efficacy as a possible means to improve overall science achievement and to reduce achievement gaps.

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Section 1: The Problem

The Local Problem

In an affluent, suburban school system in Maryland, data from standardized state science assessments indicate that few students are attaining the advanced level of proficiency. The data also reveal gaps in achievement among African American students, students receiving special education services, and economically disadvantaged students and the general student population (Maryland State Department of Education, 2014). The results of the science assessment given in fifth grade show that only 15% of all students achieved at the advanced level. In addition, when compared with the general student population, a higher percentage of African American students, special education students, and economically disadvantaged students score below the proficient level, and a lower percentage of these students score at the advanced level.

One way to address the problems of overall low student achievement and the achievement gaps is to explore the possibility that inadequacies in instructional practice are contributing to the problem. Some studies have shown that an effective way to improve instructional practice is to increase teacher self-efficacy (Briley, 2012; Hechter, 2011; Lumpe, Czerniak, Haney, & Beltyukova, 2012). High teacher self-efficacy is associated with greater commitment to teaching, more class time spent on activity based instruction, more willingness to help struggling students, and more willingness to try innovative teaching strategies (Palmer, 2011). In addition, teachers with high self-efficacy are more willing to focus on lower achieving students, take responsibility for the success of these students, and hold these students to high academic and behavioral standards results in raising the lower end of the achievement spectrum (Ross, 2013).

Rationale

Evidence of the Problem at the Local Level

The master plan of the school system stated as its goal to increase achievement for all students and close the achievement gaps between subgroups and the general student population. The subgroups of particular concern to the school system are African American students, economically disadvantaged students, and students receiving special education services. Table 1 shows the school system's test results in 2013 and 2014. Results from individual schools throughout the district indicated similar achievement gaps (Maryland State Department of Education, 2014).

Table 1

Results of the 2013 and 2014 Maryland School Assessment in Fifth-Grade Science

Student group	% Basic		% Proficient		% Advanced	
	2013	2014	2013	2014	2013	2014
All students	15	18	65	66	20	16
African American	34	39	57	54	9	7
Economically disadvantaged	28	32	65	60	7	8
Special education	62	67	36	30	<5	<5

Lack of effective science instruction for all students at the elementary school level may be contributing to the low test scores. Evidence that instructional practice may be ineffective includes the small percentage of all students attaining scores in the advanced range and the difference in performance between the general student population and several subgroups on the state science assessment. The current instruction appears to be adequate for the 15% to 20% of students performing at the advanced level, but instructional practice needs to be adapted to meet the needs of all students. Teachers who believe they have the ability to influence student outcomes are more willing to make the instructional adjustments required to increase student achievement (Johnson, 2009).

Evidence of the Problem From the Professional Literature

On the 2012 Program for International Student Achievement test in science, students in the United States underperformed compared with other developed countries (National Center for Educational Statistics, n.d.). Only 7% of U.S. students performed at the highest proficiency level compared with 27% of students in Shanghai, China, and 23% of students in Singapore. In addition, U.S. students had lower scores than students from 167 other countries and only outperformed students from 27 countries (National Center for Educational Statistics, n.d.). Disparities between the academic achievement of racial minorities and White students have been evident throughout the history of education in the United States, and current data show that these achievement gaps still exist today (Jackson & Ash, 2012; Morgan, Farkas, Hillemeier, & Maczuga, 2016; Williams, 2011). Closing achievement gaps has also been a major goal nationally since the passage of the No Child Left Behind Act of 2001 and the subsequent reauthorization of the Elementary and Secondary Education Act in 2002.

The National Assessment of Educational Progress (NAEP) is a test that assesses the achievement of eighth-grade students throughout the United States in a variety of subjects. According to Morgan et al. (2016), achievement gaps in science exhibited by eighth-grade students begin as early as kindergarten and persist throughout the elementary school years. Therefore, eighth-grade science test scores can indicate achievement in earlier school years. Table 2 shows the results of the 2011 NAEP science assessment (National Center for Education Statistics, 2012). These scores indicate that the achievement gaps evident for subgroups in the local setting are similar to those experienced by these groups nationally.

Table 2

Results of the 2011 NAEP in Science

Student group	Average score
All students	152
White	163
African American	129
Hispanic	137
Economically disadvantaged	137
Students with disabilities	128

Note. Score range 0–300.

The purpose of this study was to explore the relationship between local fifth-grade teacher inquiry science instruction self-efficacy scores and the scores of their students on the state science assessment, thus providing a possible way to address the science achievement problems.

Definition of Terms

Achievement gap: A statistically significant difference in achievement scores between groups of students (Williams, 2011).

Advanced level: Represents superior performance (National Center for Education Statistics, 2012) and indicates that a student is performing above standards. Advanced is considered a highly challenging and exemplary level of achievement (Maryland State Department of Education, 2014).

Basic level: Denotes partial mastery of prerequisite knowledge and skills that are fundamental for proficient work at each grade (National Center for Education Statistics, 2012).

Economically disadvantaged: Students eligible to receive free or reduced-price meals through the National School Lunch Program (Isenberg et al., 2013).

Inquiry instruction: A form of instruction involving students in active learning emphasizing questioning, data analysis, and critical thinking (National Committee on Science Education Standards and Assessment, National Research Council, 1996).

Proficient level: Represents solid academic performance. Students reaching this level have demonstrated competency over challenging subject matter (National Center for Education Statistics, 2012).

Self-efficacy: A person's belief that his or her performance can influence outcomes. People have little incentive to act unless they believe those actions will produce desired results (Bandura, 2000).

Significance of the Study

Goals of the local school system include increasing science achievement of all students and closing achievement gaps between subgroups and the general student population. The cost of achievement gaps at both the personal and societal levels is large, resulting in loss of income and opportunity for the lower achieving students, as well as an estimated loss of more than $1 billion per year to our national economy (Metz, 2013).

The possibility of finding a way to improve science achievement makes this study significant.

Some studies have shown that teacher self-efficacy influences student achievement (Briley, 2012; Hechter, 2011; Lumpe et al., 2012). Teachers with high self-efficacy are more willing to try new teaching strategies like inquiry-based science instruction (Palmer, 2011). Teachers with high self-efficacy ratings are more willing and able to innovate and adapt instructional approaches to include hands-on and inquiry techniques (Fogelman, McNeill, & Krajcik, 2011). The use of inquiry based instructional practices has been shown to increase overall student achievement and to decrease achievement gaps between student groups (Cotabish, Dailey, Robinson, & Hughes, 2013; Jackson & Ash, 2012; Johnson, 2009; Wilson, Taylor, Kowalski, & Carlson, 2010). Despite the large body of evidence supporting the effectiveness of using inquiry instruction, many elementary science teachers have not embraced its use in their classrooms, perhaps because of low self-efficacy (Smolleck & Mongan, 2011). This study explored the relationship between local elementary school teacher inquiry science instruction self-efficacy and student achievement as measured by their scores on the fifth-grade state science assessment. Study of this problem might be useful in the local educational setting because of the possibility that increasing teacher self-efficacy could improve student science achievement.

Research Questions and Hypotheses

Only 15% of fifth-grade students attain the advanced level of performance on the state science assessment. African American students, special education students, and economically disadvantaged students perform more poorly on the assessment than the general student population (Maryland State Department of Education, 2014). These achievement problems indicate that current instructional practices in elementary school science are not meeting the needs of all students. Research indicated teacher self-efficacy affects the effectiveness of their instruction and, consequently, may alter student achievement (Briley, 2012; Hechter, 2011; Lumpe et al., 2012). Therefore, this research will be guided by the following research questions:

RQ1: What is the relationship between teacher inquiry science instruction self-efficacy scores as measured by the Teaching Science as Inquiry (TSI) instrument and fifth-grade students' science scores on the state science assessment?

H_{01}: There is no significant relationship between teacher inquiry science instruction self-efficacy scores and students' science scores.

H_{A1}: There is a significant relationship between teacher inquiry science instruction self-efficacy scores and students' science scores.

RQ2: What is the relationship between teacher inquiry science instruction self-efficacy scores as measured by the TSI instrument and the scores of students in the three subgroups, African American, special education, and economically disadvantaged students, on the state science assessment?

H_{02}: There is no significant relationship between teacher inquiry science instruction self-efficacy ratings and the scores of students in the specified subgroups.

H_{A2}: There is a significant relationship between teacher inquiry science instruction self-efficacy ratings and the scores of students in the specified subgroups.

Review of the Literature

Theoretical Foundation

The theoretical foundation of this study is Bandura's theory of behavioral change (Bandura, 1977, 2000; Bandura & Cervone, 1983). Increasing a person's self-efficacy can result in behavioral changes (Bandura, 1977). For example, a person with higher self-efficacy may be willing to expend more effort when trying to complete a difficult task. Self-efficacy has its roots in social cognitive theory which asserts that if a person does not feel that his or her efforts will be successful, then there is little incentive to persevere when things become difficult (Bandura, 2001). People are willing to work harder, and are often more successful, when they believe they are capable of achieving positive outcomes.

There are several ways to enhance a person's self-efficacy for completion of a task. Repeatedly experiencing personal success results in increased feelings of self-efficacy that remain stable even in the face of subsequent failures (Bandura, 1977). Witnessing the success of others and verbal encouragement can also enhance self-efficacy, however, these methods are less effective than experiencing success first hand (Bandura, 1977). This theoretical framework provides the basis for this study since teacher self-efficacy affects student achievement (Briley, 2012; Corkett, Hatt, & Benevides, 2011; Guo, Connor, Yanyun Yang, Roehrig, & Morrison, 2012).

Review of the Broader Problem

The topics covered in this literature review are the current national and international trends in science achievement and the influence of various factors, especially teacher self-efficacy, on student achievement. Searches were performed using the education databases available through the Walden University library as well as through Google Scholar. Search terms included *student achievement*, *student science achievement*, *achievement gaps*, *teacher self-efficacy and student achievement*, and *inquiry science instruction and student achievement*.

Science achievement.

Inadequate student achievement in science is a concern in the United States and other parts of the world. For the past 21 years, the National Science Teachers Association (NSTA) has dedicated one issue annually of the association's professional journal to research on the topic of achievement gaps in science (Metz, 2016) indicating widespread concern in the science teaching community. The results of the 2011 NAEP in science showed that 65% of U.S. students were performing below the proficient level, and only 2% were performing at the advanced level of achievement (National Center for Education Statistics, 2012). During the last 5 years, researchers in the United States have performed numerous studies focusing on improving student achievement in science (Bolshakova, Johnson, & Czerniak, 2011; Holmes, 2011; Israel, Myers, Lamm, & Galindo-Gonzalez, 2012; Pinder, Prime, & Wilson, 2014; Pruitt & Wallace, 2012; Santau, Maerten-Rivera, & Huggins, 2011; Scott, Schroeder, Tolson, Tse-Yang Huang, & Williams, 2014; Shymansky, Wang, Annetta, Yore, & Everett, 2012; Wyss, Dolenc, Xiaoqing, & Tai, 2013). Outside of the United States, studies focusing on students' science achievement have been completed in Turkey (Atar & Atar, 2012; Demirbag & Gunel, 2014; Kablan & Kaya, 2013; Taşkın-Can, 2013); Qatar (Areepattamannil, 2012); the Baltic States (Sadi & Cakiroglu, 2011); Malaysia (Mohammadpour, 2012); Kuwait (Ebrahim, 2012); Korea

(Pahlke, Hyde, & Mertz, 2013); Taiwan and Belize (Middleton, Dupuis, & Tang, 2013); and Nigeria (Etuk, Etuk, Etudor-Eyo, & Samuel, 2011). The volume of recent research establishes low student achievement in science as a topic of widespread concern that is worthy of study at the local level. All of the researchers were interested in finding ways to improve student achievement, and they investigated several student and teacher characteristics thought to influence student learning.

Student factors associated with differences in science achievement.

In addition to low overall student achievement in science, research addressed gaps in achievement between certain subgroups of students and the general student population. The results of the 2011 NAEP assessment showed only a small difference between science scores of males and females. However, other research has determined that gender is a factor in science achievement. As shown in Table 2, the results of the 2011 NAEP determined significant differences between the levels of achievement of White students and some subgroups, particularly African American, Hispanic, economically disadvantaged students, and students with disabilities (National Center for Education Statistics, 2012).

Race and ethnicity and science achievement.

Students who belong to certain racial, ethnic, cultural or socioeconomic groups often perform more poorly on measures of achievement when compared with other students. In an urban school system in the southwestern United States, only 25% of Hispanic middle school students scored in the proficient range on a standardized science assessment compared with 63% of White students (Bolshakova et al., 2011). Similarly, Hispanic students performed more poorly than White students in a study of 80,000 high school students enrolled in CTE programs in Florida (Israel et al., 2012). In a longitudinal study that followed 21,409 kindergartners through eighth grade, achievement gaps between Hispanic and White students were seen in the results of their first standardized science assessment in third grade and persisted through eighth grade but narrowed slightly (Quinn & Cooc, 2015). In a study of 1,758 fourth-grade, English language learner (ELL) students in urban schools, Santau et al. (2011) found that they scored lower on standardized science assessments than students not classified as ELL. In the local school system, Maryland School Assessment (MSA) results from 2013 and 2014 indicated a small difference between the science scores of Hispanic students and the general student population (Maryland State Department of Education, 2014). However, the total number of Hispanic students tested was less than 60 each year. Because there are so few Hispanic students, the subgroup was not included as part of this study.

African American students consistently score lower than White students score on science assessments. In a study by Quinn and Croc (2015) that followed 21,409 students from kindergarten through eighth grade, African American students scored significantly lower than White students on science assessments starting in the third grade. This achievement gap did not narrow for the duration of the study. Similarly, African American students' scores on standardized science assessments were significantly lower than the scores of White students in studies of 80,000 high school students in Florida (Israel et al., 2012); 3,103 high school students in the southeastern United States (Pruitt & Wallace, 2012); and 4,897 fifth-grade students in Texas (Scott et al., 2014)., A study of 130 twelfth-grade students in Maryland found that Afro-Caribbean students outperformed Afro-American students on the state standardized science assessment (Pinder et al., 2014). The researchers attributed this difference in performance to differences in culture and home life of the students. The situation in the local school system mirrors the results found elsewhere: As a group, African American students consistently score below the general student population on the fifth-grade science MSA (Maryland State Department of Education, 2014).

Socioeconomic status and science achievement.

Economically disadvantaged students do not perform as well on science assessments as other students. In a study of 15,357 eighth-grade students in Malaysia, Mohammadpour (2012) found that the amount of time students spent on household chores and jobs negatively correlated with their scores on the Trends in International Mathematics and Science Study assessment. Economically disadvantaged students were disproportionately affected by this finding because they were expected to do more chores in the home and were more likely to have a job to help support their families. Students from homes with fewer available educational resources, for example, computers with Internet access, had lower scores on science assessments in a study of 7,841 eighth-grade students in Turkey (Atar & Atar, 2012). Economically disadvantaged students are more likely to live in homes with fewer educational resources. With regard to socioeconomic status and student achievement in science, students in the United States are similar to those in other parts of the world. Economically disadvantaged students scored significantly below more affluent students in a longitudinal study of 4,897 fifth-grade students in Texas (Scott et al., 2014) and a study of 6,333 high school students in the southeastern United States (Pruitt & Wallace, 2012). Mirroring the pattern seen elsewhere, economically disadvantaged students in the local school system had lower scores compared with other students on the science MSA (Maryland State Department of Education, 2014).

Students with disabilities and science achievement.

Students with disabilities, those requiring special education services, are outperformed by regular education students on science assessments. When the scores of 400 high school students from South Carolina, South Dakota, and Wyoming were analyzed, 24% of students with disabilities achieved at the proficient level compared with 72% of regular education students on a standardized science assessment (Kettler et al., 2012). Similarly, regular education students outperformed students with disabilities in a study of the science achievement of 6,333 high school students in the southeastern United States (Pruitt & Wallace, 2012). Once again, the local results are similar to those seen elsewhere. On the 2013 and 2014 science MSA, less than 40% of students with disabilities scored at or above the proficient level that was attained by more than 85% of other students (Maryland State Department of Education, 2014).

Other factors influencing student achievement.

Other school and student characteristics influence student achievement in science but were not considered in this study. Although scores on the 2011 NAEP showed only small differences between males and females (National Center for Education Statistics, 2012), other studies in the United States and elsewhere found larger gender differences. In a study of 7,841 eighth-grade students in Turkey, Atar and Atar (2012) found that gender influenced science achievement with boys outperforming girls on standardized assessments. In a study using data that followed 21,409 U.S. kindergarten students through the eighth grade, a gender gap in science achievement was evident when students took the first standardized science assessment in the third grade and only narrowed slightly by the eighth grade (Quinn & Cooc, 2015). However, no gender gap was evident in the 2013 and 2014 science MSA scores for the school system that was the focus of this study with girls slightly outperforming boys both years (Maryland State Department of Education, 2014). Therefore, gender was not explored further.

In a study of 36 students from indigenous cultures in Taiwan and Belize, the relationships between students and their teachers, the amount of classroom academic support provided to the students, and motivational support from the community were all important influences on student achievement in science (Middleton et al., 2013). Students' self-concept influenced science achievement in a study of 15,357 Malaysian eighth graders (Mohammadpour, 2012), as did students' attitude toward science in a study of 7,841 eighth graders in Turkey (Atar & Atar, 2012). The learning styles of 437 Turkish eighth graders correlated with their achievement in science. Students with learning styles associated with more easily understanding abstract concepts outperformed students who preferred learning more concrete concepts (Kablan & Kaya, 2013). Wyss et al. (2013) found that time spent reading a science textbook did not correlate with the science achievement of 2,712 high school students in the United States.

Consequences of early underachievement.

Low achievement becomes evident in the early elementary years and, if not remediated, continues to affect students' success in secondary school and beyond. Burchinal et al. (2011) followed 314 children from families with low socioeconomic status from pre-school through fifth grade. When compared with peers from families of higher socioeconomic status, the study determined that those from lower income families had lower reading and math achievement as early as three years of age, and this achievement gap persisted through the fifth grade. A study of 129 Black and 129 White students matched for other factors such as family income found that by the time they reached third grade, Black students’ achievement in reading, math, and science was significantly lower than that of White students (Simms, 2012). These findings are important because longitudinal studies following students from the early grades through high school determined that many students who fall behind do not catch up in later school years. A longitudinal study of 3,975 students in the United States determined that those who were not proficient in reading in their third grade year were four times less likely to graduate from high school (Hernandez, 2011). Similarly, a study that followed 25,948 children in Chicago public schools determined that those who were reading below grade level in the third grade were still behind in eighth-grade reading, had lower grades in high school, and had lower high school graduation rates. The consequences of the early underachievement extended beyond high school because fewer than 20% of the students who were reading below grade level in the third grade eventually enrolled in college (Lesnick, Goerge, Smithgall, & Gwynne, 2010).

Consequences of early underachievement in science.

These findings extend beyond reading and math with similar long-term achievement trends seen in science as well. In a study of 1,984 Australian high school students, prior achievement in science was the most important predictor of future achievement when compared with socioeconomic status, parental education level, class size, and attendance at public versus private schools (Keeves, Hungi, & Darmawan, 2013). Early general knowledge of science concepts was also found to be the best predictor of future performance in science in a longitudinal study that followed 7,757 United States students from kindergarten entrance through eighth grade. A student's initial level of science knowledge was predictive of their subsequent science achievement regardless of race, ethnicity, or socioeconomic status (Morgan et al., 2016). Because the science MSA is not administered until the fifth-grade, no data can be used to evaluate how early local students fall behind in science. However, the effect of early underachievement on future success is the reason why finding ways to improve student achievement in the fifth grade is so important.

Possible causes of underachievement.

Some researchers have explored possible causes of the problem of low student achievement. Factors investigated for their effects on student achievement range from parental influences (Grolnick, Raferty-Helmer, & Flamm, 2013; Jeynes, 2013; Pinder et al., 2014), to student characteristics such as physical activity (Clinton, 2013) and self-efficacy (Bong, 2013). In a study that followed more than 88,000 students in Florida from the third through the 10th grade, larger class sizes negatively affected student achievement (Burke & Sass, 2013). The same study found the achievement of peers positively correlated with individual student achievement (Burke & Sass, 2013). Although these variables were found to affect student achievement, most are beyond the control of schools and teachers.

Teacher characteristics and student achievement.

Characteristics of teachers influence student achievement. In a study of elementary students from indigenous cultures in Taiwan and Belize, the relationships teachers formed with students were identified as key factors in student achievement (Middleton et al., 2013). Similarly, in a study of 46 elementary school teachers and their ELL and economically disadvantaged students, Lopez (2012) found a positive correlation between teachers' warmth and emotional support and student achievement. Teachers' content knowledge affects student achievement in at least some subjects (Johnson, Kraft, & Papay, 2012; Metzler and Woessmann, 2012). Metzler and Woessmann compared the math and reading scores of sixth-grade teachers to the achievement of their students in these subject areas. The results were mixed: Teachers' math scores positively correlated with those of their students, but reading score results showed no significant correlation. Teacher job satisfaction positively correlated with student achievement in a study of 25,132 kindergarten through 12th-grade teachers in Massachusetts (Johnson et al., 2012).

Teacher self-efficacy and student achievement.

Teacher self-efficacy correlates with student achievement. By studying 103 teachers and 2,148 students, Muijs and Reynolds (2015) found that teacher self-efficacy affected teacher behaviors which were the best predictors of students' gains in subject matter knowledge over the course of a school year. Teacher self-efficacy is the expectation by teachers that their actions can positively influence student outcomes. Self-efficacy affected many aspects of teachers' professional behavior including goals they set for their students, to whom they attributed student success and failure, how they controlled negative feelings, and how they managed their classrooms (Ross, 2013). A research review examined 218 empirical research studies published between 1998 and 2009 including studies of teachers in 47 elementary schools, 66 middle schools, and 97 high schools. Results of the review indicated teacher self-efficacy was a major contributor to between school variance in student achievement (Klassen, Tze, Betts, & Gordon, 2011).

The relationship between teacher self-efficacy and student achievement exists for a number of content areas. In a study that compared 375 teachers and 5,170 students in South Korea to 537 teachers and 10,445 students in the United States, teacher self-efficacy was a more important factor in student achievement than other teacher factors such as college major and years of teaching experience (Ji-Won, Seong Won, Chungseo, & Oh Nam, 2016). This result was consistent across several content areas.

Teacher self-efficacy affected fifth-grade students' literacy achievement more than teachers' experience or education in a study of 898 teachers and 1,043 of their students from school systems in 10 U.S. cities (Guo et al., 2012). In a contrasting study of six Canadian sixth-grade teachers and 122 of their students, Corkett et al. (2011) found that teacher self-efficacy in the areas of reading and writing did not correlate with student performance. The designs of these two studies were quite different. The study by Guo et al. (2012) correlated archival student literacy assessment data of one randomly chosen student from each class with the teacher's self-efficacy calculated from a survey instrument. Corkett et al. (2011) administered a standardized assessment designed to measure the reading and writing abilities of all participating students at the time of the study. Different instruments were used to measure teacher self-efficacy, and neither study clearly indicated how long each student had been taught by the participating teacher. These differences in methodology make it difficult to directly compare the validity of the results from these studies and may explain the different outcomes.

Teacher self-efficacy had a strong, positive influence on student achievement in other subject areas including mathematics (Briley, 2012) and science (Lumpe et al., 2012). In a qualitative study, Katz and Stupel (2016) followed six elementary mathematics teachers over a 7-month period as they participated in workshops designed to increase the teacher instructional self-efficacy. As the teacher self-efficacy increased so did the achievement of their students. Another study that included 58 fifth-grade teachers and their 1,244 students showed that teacher self-efficacy had a significant, positive influence on students' achievement in mathematics (Yu-Liang, 2015). A similar result was found in science when Lumpe et al. (2012) studied 450 elementary school teachers and their 580 fourth-grade and 1,369 sixth-grade students. The teacher science self-efficacy scores significantly predicted their students' scores on standardized science assessments. In a review of recent research, Ross (2013) concluded that there is consistent evidence showing that teacher self-efficacy has a greater effect on student achievement than most other teacher characteristics. Therefore, this study focused on increasing teacher self-efficacy as a means to improve student achievement.

Self-efficacy and instruction.

The use of inquiry based instructional practices increases overall student achievement and decreases achievement gaps between student groups (Cotabish et al., 2013; Jackson & Ash, 2012; Johnson, 2009; Wilson et al., 2010). Use of inquiry instructional practices by science teachers significantly narrowed achievement gaps across diverse populations in a 3-year study of 32 elementary school teachers and their students in a high poverty school in Texas (Jackson & Ash, 2012). Similarly, in a 3-year study of 11 teachers and their students, Johnson found that effective, student-centered science instruction that included inquiry significantly reduced achievement gaps between African American and White students in a middle school in Ohio. In a quasi-experimental study of 144 college biology students at a community college in the Southwest United States, Jenson and Lawson (2011) found that students taught using inquiry instructional methods outperformed those taught using a more traditional lecture format. The performance gains associated with the use of inquiry methods were most significant for those students who were initially low performers. Kanter and Konstantopoulos (2010) studied nine middle-school science teachers and their students during a problem-based science course that emphasized the use of inquiry to solve real world problems. In contrast to most other studies, they found that although frequent use of inquiry instructional strategies improved students' attitudes toward science, there was not a significant, positive relationship between the frequency of use of inquiry methods and student achievement. However, a teacher's ability to support students through the inquiry process was positively related to student achievement indicating that this anomalous result may have been due to variation in the skill levels of the teachers. Because the majority of the recent literature indicated a positive relationship between use of inquiry science instruction and student achievement, this project study focused on teacher inquiry science instruction self-efficacy.

Implications

This study found significant, positive correlations between teacher inquiry science instruction self-efficacy scores and fifth-grade students' science MSA scores. As a result, the project developed is a professional development (PD) program designed to increase teacher inquiry science instruction self-efficacy. Some studies have shown that an appropriately designed and implemented PD program can achieve the goal of increasing teacher self-efficacy (Choi & Ramsey, 2009; Holden, Groulx, Bloom, & Weinburgh, 2011; Lumpe et al., 2012; Shymansky et al., 2012). Further discussion of the project appears in Section 3.

Summary

This section has presented the local problem to be studied as the existence of achievement gaps and low overall student achievement of students in elementary school science classes. The rationale for studying this problem and its significance regarding the usefulness of the results in improving student achievement were discussed. A literature review established the theoretical basis for exploring teacher self-efficacy as it relates to the problem. A further analysis of recent scholarly literature related to student achievement in science explored the broader context of the problem and provided support for the direction of this project study. A quantitative, correlational study designed to answer the research questions is found in the next section.

Section 2: The Methodology

Research Design and Approach

A quantitative, correlational research design was used to determine the relationship between science teacher inquiry science self-efficacy scores on theTSI instrument and their fifth-grade students' science scores on the MSA test. A two-tailed Pearson correlation analysis was used to determine the strength of the relationship between the continuous variables because the direction of the relationship is not predicted by the hypotheses being tested. The design of this study incorporated all of the common characteristics of explanatory correlational research as identified by Creswell (2012, p. 340):

- The investigator correlates two or more variables.
- The researcher collects data at one point in time.
- The investigator analyzes all participants as a single group.
- The researcher obtains two scores for each individual in the group, one for each variable.
- The researcher uses a correlational statistical test in the data analysis.
- The researcher makes interpretations or draws conclusions from the statistical test results.

Setting and Sample

The population consisted of all of the 30 teachers who taught fifth-grade science in the school system during the 2012–2013 and the 2013–2014 school years. In some of the elementary schools, all of the fifth-grade teachers provided science instruction. In other schools, the instruction was departmentalized with only certain teachers providing science instruction to all of the fifth-grade students. Only fifth-grade teachers who taught science were eligible to participate in the study. From the 30 eligible teachers, 22 teachers participated. Recruitment of participants and data collection followed the procedure approved by the Walden University Institutional Review Board (IRB), with the Approval Number 05-08-15-0351982. Except for teaching high school in the same school system, I had no regular contact or relationship with any of the participants. I introduced the study to potential participants during a PD session, and then the informed consent document was distributed to those who were willing to participate. Those who signed and returned the informed consent document received the TSI instrument. Eligible teachers who did not attend the PD event were contacted using the email message approved by the IRB.

An informed consent form was hand carried and placed in the school mailboxes of those who responded indicating a willingness to participate. After the participant had returned the signed consent form to me via the inter-school mail system, a TSI survey was sent back to the participant. All participants were asked to complete and return the TSI to me via the school system’s inter-school mail system. Although 28 teachers initially agreed to participate in the research, only 22 completed surveys were returned in time to be included in the data analysis. Because of the small sample size, a power analysis was performed and is discussed after the presentation of the results.

Instrumentation and Materials

The TSI instrument, a 69-item Likert scale survey developed by Smolleck, Zembal-Saul, and Yoder (2006), was used to assess teacher inquiry science instruction self-efficacy. Since the early 1990s, the Science Teaching Efficacy Belief Instrument (Enochs & Riggs, 1990) has been the instrument of choice for evaluating teacher science self-efficacy (Hechter, 2011; Lakshmanan, Heath, Perlmutter, & Elder, 2011). The TSI was developed based on the Science Teaching Efficacy Belief Instrument but focuses more closely on teacher self-efficacy related to inquiry classroom instruction making it more closely aligned with the purpose of this research. The participants responded to each of the instrument's 69 statements using a five-point scale ranging from strongly agree (5 points) to strongly disagree (1 point). The final score was determined by calculating the mean of the numerical responses with higher means indicating higher self-efficacy. The validity of the TSI as a survey instrument has been established in several studies (Heath, Lakshmanan, Perlmutter, & Davis, 2010; Smolleck & Yoder, 2008; Smolleck et al., 2006). The construct and content validities of the instrument were established through multiple reviews of six revisions of the survey by expert faculty members from several universities (Smolleck et al., 2006). The TSI was then administered to 190 preservice teachers, and the results were analyzed to determine the construct validity of the items and how each item contributed to the reliability of the survey instrument. The Coefficient alpha statistic was used to evaluate the reliability of the instrument, and the results were used to develop the final version of the TSI. Coefficient alpha values for the subscales ranged from 0.6034 to 0.7833 indicating that the internal consistency of the final version complied with the standards for first generation survey instruments (Smolleck et al., 2006, p. 153). In an additional study, Smolleck and Yoder (2008) found that all 69 items contributed to the TSI survey's construct and content validity and high internal reliability producing Coefficient alpha values for self-efficacy of .9441 pretest and .8911 posttest and outcome expectancy alphas of .9023 pretest and .9029 posttest. Heath et al. (2010) evaluated 11 survey instruments and determined the TSI to be the most appropriate instrument. A full version of the TSI is included as Appendix B. The letter used to obtain permission from the developer, Smolleck, to use the TSI is included in Appendix C. For the second variable, student scores, the archival results of the state criterion-referenced science assessment available from the school system were used. Scores were obtained for all fifth-grade students taught by the participating teachers. The data indicated each student's race and whether or not the student required special education services or was economically disadvantaged.

Data Analysis Results

Teacher inquiry science instruction self-efficacy scores were determined from the TSI surveys completed by each of the 22 participating teachers. Student achievement data from the state science assessment test, disaggregated by subgroup and teacher, was supplied by the local board of education. The subgroups included are those of special interest to the school system based on previous test results indicating achievement gaps between these subgroups and the general student population. Other subgroups, such as Hispanic and Native American students, were not included because of the very small numbers of these students in the school system. Scores were obtained for a total of 1,625 fifth-grade students of which 177 were African American, 125 received special education services, and 386 were economically disadvantaged. Although some African American students were also members of the other subgroups, they comprised less than 25% of both the special education and the economically disadvantaged subgroups. Permission from the local school board was obtained to use these data.

IBM SPSS Statistics 21 software was used to perform data analysis to evaluate whether to accept or reject the following null hypotheses:

H_{01}: There is no significant relationship between teacher inquiry science instruction self-efficacy scores and students' science scores.

H_{02}: There is no significant relationship between teacher inquiry science instruction self-efficacy ratings and the scores of students in the specified subgroups.

Teacher inquiry science instruction self-efficacy was correlated with the test scores of all students as well as with the test scores of each of the subgroups. Both variables, teacher self-efficacy scores from the TSI Likert scale survey instrument and criterion referenced state science exam scores, which can range from 240 to 650 (Maryland State Department of Education, 2007), are interval scale variables (Creswell, 2012). The Pearson correlation coefficient (*r*) was used for analyzing this data because only one independent variable, student test score, was studied. An interpretation regarding the strength of the association between the variables was made based on comparing the calculated *r* value to the critical *r* value (Creswell, 2012).

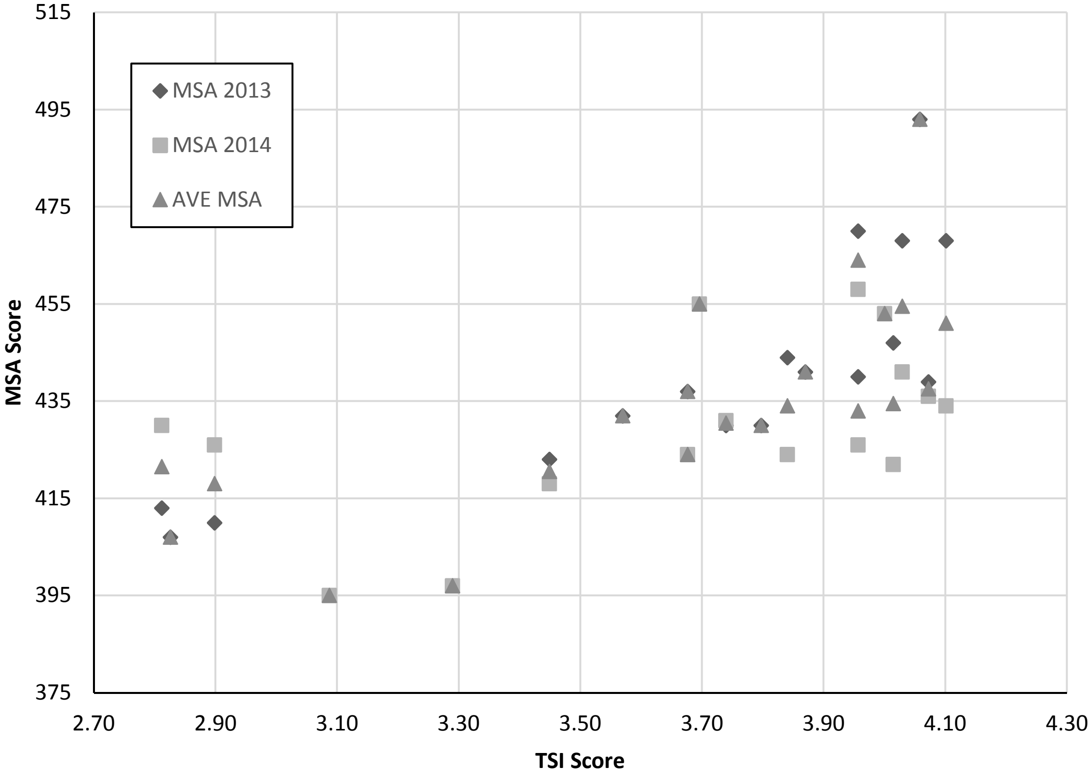

Figure 1. Scatter plot comparing scores. The figure shows a comparison between teacher scores on the TSI to the average score of all of their students on the science MSA examinations administered in 2013, 2014, and the average of the scores for both years.

Figure 1 shows a direct, positive relationship between teacher inquiry science instruction self-efficacy scores and their students' scores on the science MSA examinations administered in 2103 and 2014, as well as when the two years' data were averaged. As shown in Table 3, the results of a two-tailed Pearson correlation analysis indicate that the correlations between the TSI scores and both the 2103 data ($r_{15} = .801$) and the average data ($r_{20} = .724$) are significant at the $p < .01$ level. The correlation between the TSI scores and the 2014 data ($r_{14} = .509$) is slightly lower but still significant at the $p < .05$ level. Because the sample size was small, a post hoc power analysis was performed using the G*power software developed by Faul, Erdfelder, Buchner, and Lang (2009) to ensure the statistical power of the result exceeded the accepted value of .8 (Cohen, 1992). As seen in Table 3, based on the sample sizes, effect sizes calculated from the r values, and $p = .05$, the power was greater than .95 for the 2013, 2014, and the average data sets. Based on these results, the first null hypothesis stating that there is no significant relationship between teacher inquiry science instruction self-efficacy scores and student scores is rejected.

Table 3

Summary of Pearson Correlation Coefficients for Teacher Scores on the TSI Versus Student Science MSA Scores From the 2013 and 2014 Administrations

Student groups	MSA 2013	MSA 2014	MSA Average	AA	SPED	ED
TSI (by student group)	.801**	.509*	.724**	.549**	.532*	.659**
n	17	16	22	22	20	22
Power	.99	.97	.99	.99	.99	.99

Note. TSI = Teaching Science as Inquiry Inventory; MSA = Maryland School Assessment; AA = African American; SPED = Special Education; ED = Economically Disadvantaged
*$p < .05$; **$p < .01$.

Direct, positive relationships exist between teacher scores on the TSI survey instrument and the MSA scores of African American students, students receiving special education services, and economically disadvantaged students. Because of the relatively small numbers of students in these groups, only the average of the 2013 and 2014 data was analyzed. The results of the two-tailed Pearson correlation analysis shown in Table 3 indicate statistically significant correlations between teacher TSI scores and the MSA scores of all three subgroups. As shown in Table 3, the results of a two-tailed Pearson correlation analysis indicate that the correlations between the TSI scores and the MSA scores of African American students ($r_{20} = .549$) and economically disadvantaged students ($r_{20} = .659$) are significant at the $p < .01$ level. The correlation between the TSI scores and the scores of students with disabilities ($r_{18} = .532$) is slightly lower but still significant at the $p < .05$ level. Because the sample size was small, a *post hoc* power analysis was performed using the G*power software developed by Faul, et al. (2009) to ensure the statistical power of the result exceeded the accepted value of .8 (Cohen, 1992). As seen in Table 3, based on the sample sizes, effect sizes calculated from the r values, and $p = .05$, the power was .99 for all three subgroups. Crossover of students between subgroups was found to be less than 25%, and the relationship between teacher TSI scores and student scores is highly significant for each of the subgroups. Based on these results, the second null hypothesis stating that there is no significant relationship between teacher inquiry science instruction self-efficacy scores and the MSA scores of students in subgroups is rejected.

Assumptions, Limitations, Scope, and Delimitations

Because quantitative research is rooted in the positivist world view, any quantitative study is based on the assumption that human behavior can be explained objectively, and that there exists an objective reality beyond each individual’s subjective world view (Firestone, 1987). Regarding data collection, it was assumed that teacher participants understood the scale of the TSI survey and took the time to complete the survey honestly and accurately. It is assumed that the state testing data accurately reflect the achievement level of students in fifth-grade science and that the tests were administered using standard procedures in each school and with each group of students within each school.

Limitations are factors that, as a result of the study design and setting, are beyond the control of the researcher (Simon & Goes, 2013). As is true of any correlational study, the results of this research establish the strength of the relationship between the variables but cannot provide evidence that one variable is the cause of the change in the other variable. In other words, the study is limited by only showing an association between the variables, not a causal relationship. Confounding variables may affect the relationship between the variables under study (Mitchell, 1985). For example, some schools have a higher percentage of students with low socioeconomic status. This factor may have significantly affected student achievement regardless of the self-efficacy of the teacher. Another possible confounding variable results from the fact that some students are members of more than one of the subgroups studied.

A limitation was the small population. Even though 73% of invited teachers participated in the study, the Pearson correlation was run with the TSI scores from 22 teachers and their students which is slightly below what is ideal for correlational research results. However, the IBM SPSS software considered the sample size when producing the p value required to indicate a significant relationship because the critical value for r is determined based on the sample size. Although both the Pearson correlation coefficient analysis and the power determination indicate a significant relationship between the variables, the results should be viewed with caution due to the small sample size. In addition, a construct validity problem may result if non-responding teachers as a group were different in some way from those who participated (Mitchell, 1985). Since the research was conducted on a small scale in a local system with a limited number of participants, the results are not generalizable beyond the local setting or to other grade levels.

The scope of this study was to determine the relationship between fifth-grade science teacher inquiry science instruction self-efficacy and their students' achievement as measured by their scores on a state-administered standardized assessment. Delimitations are boundaries to the study as a result of choices made by the researcher (Simon & Goes, 2013). My desire to perform a quantitative research study comparing two variables limited the research to a correlational study. Further research would be required to rule out other possible explanations for the observed relationship and establish causality. The focus on teacher inquiry science instruction self-efficacy limited the choice of appropriate survey instruments to the TSI, and use of the TSI limited the scope of the research to elementary school teachers as it is not validated for use with other grade levels. The need for an objective measure of student achievement in science limited the scope to fifth-grade teachers and students because only fifth-grade students take a standardized science exam in the elementary grades in Maryland.

Protection of Participants' Rights

Although I needed to know individual teacher identities to correlate results of the survey and student test scores, teachers' identities were protected by use of an alphanumeric code known only to me. Any data that can be traced to any individual will be kept in a locked cabinet and destroyed after 5 years. Informed consent was obtained from each participating teacher and will be kept on file for the duration of the study and at least 5 years afterward per U.S. Department of Health and Human Services regulation (45 CFR 46.115(b)) and Walden University's IRB requirements.

Data were obtained only for groups of students, and students were never individually identified. Because only archival student data were used, no informed consent and assent were needed.

Section 3: The Project

Introduction

Teacher self-efficacy influences student achievement (Briley, 2012; Guo et al., 2012; Ji-Won et al., 2016; Klassen et al., 2011; Lumpe et al., 2012). The current study in a school system in Maryland corroborated earlier findings.The results of the research in Section 2 showed a significant positive relationship between teacher inquiry science instruction self-efficacy scores and the scores of their students on a standardized science assessment.

The findings from this study were used to design a project in the form of a PD plan aimed at improving teacher inquiry science instruction self-efficacy. This section includes a description of the project, including the goals and rationale, and a review of the current literature supporting the project choice and design. A plan for project implementation and evaluation is also included. Finally, the implications of the project for social change in the local community and beyond are discussed.

Description and Goals

The project resulting from this study is a PD training plan for fifth-grade science teachers. The PD described in detail in Appendix A will provide the teachers with training in strategies needed to implement inquiry science instruction successfully which might increase teacher self-efficacy. Participating teachers will have opportunities to observe strategies and techniques used by teachers who are proficient at inquiry science instruction. The participants will then work cooperatively with workshop instructors and other teachers to develop and implement several inquiry based science lessons.

Rationale

The administration of the local school system has identified the achievement of fifth-grade students on the state science assessment as a problem. In addition, administrators support PD that would also reduce the difference in achievement between all students and the students in subgroups. The research presented in Section 2 established a significant, positive relationship between teacher inquiry science instruction self-efficacy scores and their students' scores on the assessment. The relationship between these variables was found to be significant for all of a teacher's students, as well as for students in several subgroups: (a) African American students; (b) economically disadvantaged students; and (c) students receiving special education services. Because of the relationship established between teacher inquiry science instruction self-efficacy and student scores, a project designed to increase teacher self-efficacy regarding the teaching of science as inquiry was chosen.

Based on the results of a literature review, teacher PD is an effective way to increase teacher self-efficacy. The current research contains numerous examples of the positive effect of participation in PD activities on teacher self-efficacy (Ross, 2014; Shu Chien & Franklin, 2011; Tatar & Buldur, 2013; Tzivinikou, 2015). After further research to determine the format and duration of the PD activities most effective at increasing teacher self-efficacy, a plan was developed to provide the fifth-grade science teachers with a training experience designed to increase their inquiry science instruction self-efficacy. Hopefully, increasing teacher self-efficacy will, in turn, increase the MSA science scores of all of their students, and decrease the gaps in scores between all students and the students in the targeted subgroups.

Review of the Literature

This literature review focused on defining PD, the features of effective PD, and exploring the evidence that PD is effective in increasing teacher self-efficacy. The effect of participation in PD on teacher self-efficacy, in general, was examined before honing in on specific research demonstrating the improvement of inquiry science instruction self-efficacy as a result of PD experiences. Factors influencing the effectiveness of PD were also explored, and the results were used to craft a PD plan of the optimal type, format, and duration. Finally, methods for evaluating the effectiveness of PD activities were researched. Relevant current literature was accessed using the Walden University library educational databases and Google Scholar using the following search terms: *professional development, PD and self-efficacy, PD and teacher self-efficacy, PD and teacher self-efficacy and science instruction, PD and science teacher self-efficacy and inquiry, PD and collaboration and self-efficacy, and PD and evaluation*.

In addition, the reference lists of several recent reviews of the literature on PD in science (Capps, Crawford, & Constas, 2012; Gerard, Varma, Corliss, & Linn, 2011; Luft & Hewson, 2014; van Driel, Meirink, van Veen, & Zwart, 2012) were mined for relevant sources.

Professional Development

Because learning needs to extend beyond college, and because we live in an age of rapidly evolving knowledge, the need for training throughout a professional’s career is recognized across many professions including teaching (Webster-Wright, 2009). In education, PD can be defined as any activity that is designed to improve the performance of school staff (Desimone, 2009). In a recent publication by the National Academy of Sciences (2015) PD is defined as “learning experiences for teachers that (1) are purposefully designed to support particular kinds of teacher change; (2) include a focused, multiday session for teachers that takes place outside of the teacher’s classroom or school; (3) may include follow-up opportunities over the school year; and (4) have a finite duration” (p. 115). Providing continuing learning in the form of PD is considered to be a key component in improving teacher quality and, thus, positively affecting student learning (Opfer & Pedder, 2011).

PD activities come in many forms varying from attendance at local and national conferences and formal presentations on PD days to more casual school-based professional learning community collaborative meetings and participation in online learning activities (Desimone, 2009). Despite the format, effective PD programs share some common qualities and practices. Good PD should provide teachers with understanding and skills necessary for good classroom practice (Riggsbee, Malone, & Straus, 2012). PD must be continuous and orderly to positively affect student achievement (Sappington, Pacha, Baker, & Gardner, 2012). Based on a research base of correlational studies and self-reporting by teachers (Wilson, 2013), the common features of effective PD include content focus, active learning, coherence, sufficient duration, and collective participation (Desimone, 2009; Main, Pendergast, & Virtue, 2015; National Academies of Sciences, Engineering, and Medicine, 2015). Referred to as the consensus model of PD, these features of effective PD are described more thoroughly by the National Academy of Sciences (2015) report as follows:

> - Content focus- learning opportunities for teachers that focus on subject matter content and how students learn that content.
> - Active learning- can take a number of forms, including observing expert teachers, followed by interactive feedback and discussion, reviewing student work, or leading discussions.
> - Coherence- consistency with other learning experiences and with school, district, and state policy
> - Sufficient duration- both the total number of hours and the span of time over which the hours take place.
> - Collective participation- participation of teachers from the same school, grade, or department. (p. 118)

To the extent possible, teachers should be provided with choices of PD options designed to match varying learning styles rather than being subjected to a "one size fits all" approach. Martin, Kolomitro, and Lam (2014) reviewed 94 articles on workplace training methods. They concluded that the needs and characteristics of the workers were important considerations in planning effective training activities. Results of a survey completed by 1,052 Saudi Arabian science teachers revealed a wide variation in their preferences regarding the most effective PD (El-Deghaidy, Mansour, Aldahmash, & Alshamrani, 2015). In a study of 25 teachers in New Zealand, Petrie and McGee (2012) found that teacher learning is maximized when PD uses the methods by which each teacher learns best.

Collaboration among participants, both during and after the PD activity, and the opportunity for teachers to reflect on what they have learned, are important features of effective PD. In a qualitative study of four Spanish teachers, providing the time and opportunity for collaboration and reflection improved the teachers' instructional practice (Burke, 2013). Collaboration with experts can benefit less experienced teachers. When partnered with university astronomy faculty, public school teachers became more confident and developed improved attitudes about teaching an astronomy unit (Burrows, 2015). Similarly, when 15 high school content area teachers were each paired with a special education teacher their collaboration resulted in a significant increase in the content area teachers' effectiveness in providing appropriate accommodations for special education students (Tzivinikou, 2015). Taking this research into consideration, the PD plan developed for this project study provides participants with multiple opportunities to collaborate and reflect on their learning.

There is little consensus when it comes to the relationship between the duration of PD activities and their effectiveness (National Academies of Sciences, Engineering, and Medicine, 2015). One review of the PD literature suggests that a minimum of 20 hours is needed for a program to be effective (Desimone, 2009). Other studies have found 1-week long summer workshops with follow-up sessions throughout the subsequent school year to be effective. Powell-Moman and Brown-Schild (2011) followed 31 teachers who participated in a PD program in North Carolina. The teachers spent a week during the summer working with scientists to develop science lessons and then had additional access to the scientists as they implemented the lessons during the subsequent school year. Participation in the program resulted in a significant increase in the teacher self-efficacy for science instruction. Similarly, 44 kindergarten through second-grade teachers from small, rural school districts in California achieved significant gains in their science content knowledge and self-efficacy after participation in a 6-day summer PD program (Sandholtz & Ringstaff, 2014). After reviewing the recent literature, Opfer and Pedder (2011) concluded the most effective PD was intensive and sustained over a few days. As a result of these findings, the proposed PD activity will consist of a total of 28 hours of instruction during four consecutive 7-hour days.

Appropriate PD is especially important for success when teachers are required to implement new curriculum or teaching practices (Burke, 2013; Stolk, De Jong, Bulte, & Pilot, 2011) such as shifting to an inquiry based instructional approach in science (El-Deghaidy et al., 2015; Wilson, 2013). Polly (2015) found that participation in a PD program resulted in increased use of student centered tasks by elementary school mathematics teachers producing an increase in student understanding of concepts. Similarly, Burke (2013) found that foreign language teachers were more able to implement innovative classroom methods after participation in a PD program. The fifth-grade teachers that are the subjects of this study are being asked to modify their classroom instructional practice and implement new instructional methods. Based on the current literature, a well designed PD program should be effective in helping them make the required changes.

PD and Teacher Self-Efficacy

The results of the data collection and analysis shown in Section 2 indicate a significant, direct relationship between the fifth-grade science teacher inquiry science instruction self-efficacy scores and the MSA scores of their students. A review of the current literature reveals many studies, discussed in the next section, showing that PD is an effective way to improve teacher self-efficacy.

Use of Observation and Practice to Increase Self-Efficacy

Features common to PD programs that produce improvements in self-efficacy include the use of observation and practice. According to Bandura (1977), there are several effective methods for improving self-efficacy. Both witnessing the success of others and verbal encouragement can enhance self-efficacy. However, these methods are less effective than experiencing success first hand. Repeatedly experiencing personal success results in increased feelings of self-efficacy that remain stable even in the face of subsequent failures. These methods of improving self-efficacy have been harnessed in the design of some PD programs that were effective in increasing teacher self-efficacy. Participation in PD that included observing other teachers experience success increased the self-efficacy of the observers. Similarly, PD programs that allowed teachers to participate in hands-on practice of new instructional technologies or strategies significantly increased the participants' self-efficacy.

Studies of teachers across various content areas and grade levels support the contention that both observation of others and hands-on experience are useful ways to increase teacher self-efficacy. Shu Chien and Franklin (2011) found that hands-on practice with new computer applications significantly increased teachers' feelings of self-efficacy regarding using the applications in their classrooms. They also found that teacher self-efficacy concerning the use of the applications was the strongest predictor of subsequent classroom use of the technology. In a study of a PD program designed to promote the use of alternative forms of assessment, first observing other teachers successfully using alternative assessments followed by practice designing and administering these types of assessments significantly increased teachers' feelings of self-efficacy regarding their use (Tatar & Buldur, 2013). Dixon, Yssel, McConnell, and Hardin (2014) found that, regardless of content area or grade level taught, practice with new teaching strategies during a PD experience produced a sense of familiarity that resulted in an increase in teacher self-efficacy. Although, Ross (2014) did not find participation in PD with an unspecified format to be effective in increasing the self-efficacy of teachers for instruction of mathematics to ELL students, another study of PD that required teachers to work through complex mathematics problems for themselves increased the participating teacher self-efficacy regarding differentiating classroom instruction for gifted learners (Levenson & Gal, 2013).

Studies focused on improving the self-efficacy of science teachers have shown that observation of the success of others and hands-on practice with new instructional techniques were effective PD strategies. A PD program that combined content instruction, observation of experienced teachers, and hands-on development and use of inquiry based lessons significantly increased elementary school science teacher self-efficacy concerning inquiry based science instruction (Sandholtz & Ringstaff, 2014). A teacher participant summed up the program's success with the comment "Being able to see the teachers give the lesson at our grade level at the summer institute showed me I could do that exact same thing... when the teachers showed me exactly what to do, it was like, 'Oh, I could do that.'" (p. 744). A study of more than 100 kindergarten through 12-grade teachers who participated in a hands-on PD program that provided opportunities for them to model and enact the practices of inquiry science showed a significant increase in the teacher self-efficacy (Enderle et al., 2014). Similarly, participation in a PD summer institute that included the hands-on manipulation of laboratory teaching materials significantly increased the participants', who were mostly teachers of grades 4 through 8, science teaching self-efficacy (Sinclair, Naizer, & Ledbetter, 2011). In another example of the effectiveness of hands-on PD activities, pre-service elementary school teachers who completed a course in inquiry based science instruction including firsthand experiences using inquiry instructional techniques and materials of instruction exhibited increased self-efficacy for science instruction as measured by a pre- and post-survey (Avery & Meyer, 2012; Bergman & Morphew, 2015). Powell-Moman and Brown-Schild (2011) and Lumpe et al. (2012) found that participation in summer PD programs emphasizing practicing the use of inquiry based instruction significantly increased teacher self-efficacy concerning inquiry science instruction. The results of these studies indicate that a PD program aimed at increasing teacher inquiry science instruction self-efficacy should include: (a) observation of more experienced teachers; (b) practice with hands-on inquiry based activities; and (c) practice using inquiry instructional techniques and materials. Thus, these are key components of the proposed PD program.

Effect of Collaboration on Self-Efficacy

Collaboration with fellow teachers is a necessary part of both the active learning and the collective participation components of the consensus PD model. Verbal encouragement by respected peers was recognized by Bandura (1977) as a method to increase teacher self-efficacy. Some studies have shown the positive effect of teacher collaboration on increasing self-efficacy. In a PD technique referred to as “Lesson Study” (Howell & Saye, 2016) teachers collaborate to develop and refine a lesson by observing each other teaching and then discussing ways to improve instructional practice. In a qualitative study of 10 teachers in Singapore, Chong and Kong (2012) found that participation in the Lesson Study collaborative process increased the participating teacher instructional self-efficacy. Providing science teachers the opportunity to collaborate on developing inquiry-based lessons during PD may result in similar gains in self-efficacy, and the proposed plan provides several such opportunities.

In another example of the positive effect of collaboration, 15 high school content area teachers were paired with special education teachers to develop lessons and instructional strategies to more effectively serve mainstreamed special education students. Their collaboration resulted in a significant increase in the content area teacher self-efficacy regarding teaching special education students (Tzivinikou, 2015). Similarly, several studies of research experience for teachers PD programs featuring collaboration between science teachers and professional scientists resulted in an increase in the teacher science instructional self-efficacy (Enderle et al., 2014; Saka, 2013). Participation in a summer PD experience during which science teachers worked with mentor scientists to develop inquiry-based instructional materials also increased the science teacher self-efficacy (Powell-Moman & Brown-Schild, 2011). A similar effect on elementary school science teacher self-efficacy might be achieved by pairing them with high school science teachers who act as mentors during PD. For this reason, high school science teachers from within the school system will be employed as facilitators and mentors in the proposed PD plan.

Project Description

The project will consist of PD activities provided on four consecutive 7-hour days during the summer break. Current research suggests that to be effective, the duration of a PD program needs to be at least 20 hours (Desimone, 2009). The four consecutive days will provide 28 hours of PD time. As previously discussed, some studies have found summer workshops to be effective formats for PD (Powell-Moman & Brown-Schild, 2011; Sandholtz & Ringstaff, 2014; Sinclair et al., 2011), and the most effective PD appears to be intensive and sustained over a few days (Opfer & Pedder, 2011). Therefore, this PD plan follows that format.

Potential Resources and Existing Supports

The objective of this PD program is to improve fifth-grade science teacher inquiry science instruction self-efficacy. Based on the results of my research, this may result in improvement in the science MSA scores of all students including those in the subgroups of concern to the school system. Because the objective of the PD program aligns closely with a major stated goal of the school system, there should be significant support from the administration. I worked closely with the elementary science instructional supervisor when I was conducting my research. She is, therefore, very interested in my research topic and the results of my investigation and will be supportive of the plan to provide PD to the fifth-grade science teachers. The school system regularly provides funding for PD activities for teachers during the summer months. Because school system employees will provide the leadership for the PD, no funding will be needed to bring in outside experts or speakers which would be significantly more expensive.

The PD program requires little in the way of physical resources. The program can be held in one of the local high schools providing sufficient lab space at no cost to the school system. All of the materials required for the lab activities are available at any big box store for minimal cost. Copies of the paperwork for the workshop can be made in a school office for minimal cost.

Potential Barriers

Because the PD will occur during the summer break, one potential barrier to successful implementation is the possibility that teachers will not be willing or able to give up a week of their vacation to participate. This problem could be minimized by announcing the PD dates early enough for teachers to plan their activities around them. Providing teachers with information regarding the nature of the training and the potential benefit for them and their students should also encourage teachers to attend. By ensuring that at least one teacher from each school participates, this barrier could be partially overcome. That teacher could then share the knowledge and activities from the PD with those who were absent.

Another potential barrier is funding for the PD. When teachers attend PD activities during the summer break, the school system pays them at a per diem rate. It may be difficult to secure the level of funding required for all of the 30 or so teachers to attend. If funding becomes an issue, it may be necessary to look at student scores and focus on teachers whose students are having the least success on the science MSA. These teachers would be the highest priority for participation in the PD program.

Proposal for Implementation and Timetable

For the reasons previously discussed, the PD program will take place during four consecutive 7-hour days during the teachers' summer break. The first day will consist of introductions, explanation of the purpose of the program and the agenda, the pre-assessment TSI survey administration, and several hands-on activities designed to familiarize the participants with teaching science as inquiry. Days two and three are designed to give the participants first-hand experience with inquiry instructional strategies by observing high school teachers presenting inquiry based science lessons. The high school teachers chosen as mentors for the PD program will be those who have extensive experience and skill in inquiry instructional strategies. The mentor teachers will model the presentation of inquiry based lessons with the participants acting as the students. Participants will spend the final day collaborating with their fellow fifth-grade teachers and the high school mentor teachers to adapt several lessons currently used as part of the fifth-grade science curriculum, making them inquiry based. Finally, the participants will complete the post-assessment TSI survey that will be used to evaluate the effectiveness of the PD program. A more detailed description of the PD program is found in Appendix A.

Roles and Responsibilities of Student and Others

It will be my responsibility to present the PD proposal to the school system administration to garner support for the program. I will start with the elementary science instructional supervisor who has already been supportive of my work, and we will approach the administration together. The elementary science supervisor, once on board, will need to market the program to the fifth-grade science teachers. Because I teach science at the high school level, I will recruit several of my fellow high school science teachers to work as mentors. The supervisor and I will share the responsibility of acquiring space and materials for the program, as well as the facilitation of the program activities.

Project Evaluation Plan

Effective professional learning is enhanced by monitoring and evaluation of outcomes based on data (Learning Forward, n.d.). The TSI instrument, as used by Smolleck and Yoder (2008), has been shown to be a valid assessment tool. The TSI will be administered before and at the conclusion of the PD institute, and the results will be analyzed to determine if a significant gain in self-efficacy is achieved. The need for individualized follow up will be assessed based on the results. Based on the data shown in Section 2, it appears that the students of teachers who score 3.60 or greater on the TSI enjoy greater success on the MSA science assessment. Teachers whose TSI results remain below this level following the PD summer institute may require more training and support. These teachers will be given the option of working with a mentor teacher, one who has high self-efficacy scores and a history of producing highly successful students, throughout the following school year.

Project Implications

Local Community

Increasing achievement for all students and closing the achievement gaps between subgroups and the general student population is a goal of the school system. The subgroups of particular concern to the school system are African American students, economically disadvantaged students, and students receiving special education services. The results of the research shown in Section 2 indicate a strong, positive relationship between fifth-grade teacher inquiry science instruction self-efficacy and the scores of their students on the science MSA. Participating in this PD opportunity should increase the teacher inquiry science instructional self-efficacy, possibly resulting in an increase in achievement for all of their students and a reduction in the achievement gaps currently seen among the general student population and African American students, economically disadvantaged students, and students receiving special education services.

Improving student achievement has implications for students, their families, the school system and the community. Success in the elementary grades is a predictor of future school success. Students who experience academic success are more likely to remain engaged in the learning process and to set higher academic goals for their future (Greene, Miller, Crowson, Duke, & Akey, 2004). Failure in secondary school is the result of disengagement from the learning process due to lack of academic success throughout the elementary and middle school years (Alexander, Entwisle, & Horsey, 1997). There is a strong relationship between elementary school achievement and completion of high school (Jimerson, Egeland, Sroufe, & Carlson, 2000). The increase in teacher self-efficacy resulting from this PD project may translate into increased student success at the elementary school level followed by a greater chance of successful completion of high school.

Far-Reaching

Congress has recognized the failure of the United States educational system to produce enough qualified scientists and engineers to meet the needs of our society, and significant amounts of money and resources have been expended with the objective of encouraging more students to enter these career fields (Kuenzi, 2008). The lack of qualified scientists and engineers in the United States is the result of relatively few students pursuing science, technology, engineering and mathematics (STEM) college degree programs and careers. Exposing elementary school students to positive STEM experiences, allowing them to feel successful in science, positively affects their perceptions of science and may be crucial in encouraging more students to pursue STEM careers (Dejarnette, 2012). This PD project may result in increasing elementary school science achievement, thus providing more students with the academic preparation and positive attitude needed to encourage them to pursue STEM careers.

The cost of achievement gaps at both the personal and societal levels is large, resulting in loss of income and opportunity for the lower achieving students, as well as an estimated loss of more than $1 billion per year to our national economy (Metz, 2013).

The increase in teacher self-efficacy resulting from participation in this PD program may produce higher achievement among African American, economically disadvantaged, and special education students thus reducing the achievement gaps between these groups and the general student population.

Conclusion

In this section, a PD program designed to improve fifth-grade science teacher inquiry science instruction self-efficacy was described, and the rationale for choosing this project was explained. The current literature relevant to such a PD program was reviewed, and the results were applied in the planning of the design, implementation, and evaluation of the PD project. Implications of the project for students, teachers, the community, and society as a whole were discussed.

In the next section, the project's strengths and limitations are described, and methods for remediating any limitations are discussed. An analysis of what I have learned in the process of developing this project is included. Finally, the potential implications of the project for social change are evaluated, and possible directions for future research arediscussed.

Section 4: Reflections and Conclusions

Introduction

In this section, I will evaluate the strengths and limitations of the proposed PD project and recommend ways in which the project's limitations may be remediated. I will reflect on what I learned as a result of developing this project study in the areas of scholarship, project development and evaluation, and leadership and change. I will analyze my development as a scholar, as a practitioner, and as a project developer. I will discuss the project's potential for social change. Finally, I will describe the project's implications and propose possible directions for future research.

Project Strengths and Limitations

My review of the current literature revealed that low student achievement in science is a problem both nationally and locally. At the local level, state standardized science assessment results indicate that African American, economically disadvantaged, and special needs students perform at well below the level of the general student population. In addition, only a small percentage of all students perform at the advanced level. The results of my research indicate that teacher inquiry science instruction self-efficacy has a significant positive relationship with student MSA scores in science. Because its design is based on effective PD recommendations from the current literature, the proposed PD project should result in an increase in the participants' inquiry science instruction self-efficacy. This increase in teacher self-efficacy should translate into more effective inquiry based classroom instruction, and a resultant increase in student achievement in science.

The proposed project faces some limitations in addressing the problem of low science achievement. One potential problem is the inability or unwillingness of teachers to participate in the PD because the program will take place during the summer break. Recruitment efforts will need to stress the positive outcomes expected regarding student success in the hope that teachers will see the value of the program and want to participate. Another potential limitation is the willingness of the school system to provide funding for the project. Increasing student achievement and reducing achievement gaps is a primary goal of the school system. The elementary science supervisor and I will need to make a strong case to administrators emphasizing the potential benefits of the PD program regarding achieving this goal.

Recommendations for Alternative Approaches

An alternative proposal for addressing the problem would be to hold the PD program on teacher work days already scheduled within the school year. However, the literature (Lumpe et al., 2012; Powell-Moman & Brown-Schild, 2011) suggests that the summer institute model is more effective when it comes to increasing teacher self-efficacy. Another possibility would be to provide part of the program as an online course. The literature (Enderle et al., 2014; Saka, 2013; Tzivinikou, 2015) suggests that an approach that allows teachers to collaborate and practice in a hands-on environment is the most effective way to increase self-efficacy, so an online approach may not be as effective as a face-to-face experience.

Scholarship

The Merriam-Webster dictionary defines a *scholar* as “a person who has studied a subject for a long time and knows a lot about it” or “a person who has done advanced study in a special field.” As a result of completing this project study, I believe I now can be called a scholar concerning the relationship between teacher inquiry science instruction self-efficacy and student achievement. I learned that becoming a scholar requires spending many long hours researching, reading and synthesizing the literature to develop a basis for understanding the results and implications of current research in my area of interest. Only after digesting the work of others was I able to formulate research questions and propose and carry out appropriate research to answer them. Based on the results of my research, I again had to delve into the literature to seek a research based solution in the form of a PD program. Thus, any new scholarship must be based on the foundation laid by others.

Project Development and Evaluation

The choice of project genre and the design of the project were based on the results of the review of the current literature as well as the results of my original research. The project should provide the local school system with a new way to improve teaching and learning. Because my research revealed a positive relationship between teacher inquiry science instruction self-efficacy and student MSA scores, I looked in the literature for effective ways to increase teacher self-efficacy. A PD project was chosen and designed based on the information found. I learned that there is much variation in the methodologies used by researchers in evaluating the effectiveness of PD projects.

However, most sources agreed on several characteristics of effective PD programs. These factors were taken into consideration when designing the PD activity. Since the objective of the PD activity is increasing teacher self-efficacy, the evaluation method I chose is a Likert scale survey that directly measures this variable. The survey will be given both before and at the conclusion of the PD program allowing assessment of the effectiveness of the program.

Leadership and Change

Traditionally, school leadership was the responsibility of the administrators, but schools can benefit from recruiting classroom teachers to serve in some leadership roles. Master teachers can act as teacher-leaders by mentoring less experienced colleagues or facilitating PD opportunities in their areas of expertise (Boyd-Dimock & McGree, 1995). These teacher-leaders can be a force for positive change by helping to improve the quality of instruction throughout the school. Administrators who encourage teachers to be leaders in the school, and who can effectively utilize the skills of their most effective teachers as leaders, have the most success when it comes to improving student achievement (Branch, Hanushek, & Rivkin, 2013). Great teaching depends on teachers being comfortable with being the leaders in their classrooms. These teacher leaders set ambitious goals and provide the leadership needed for students to attain them (Farr, 2010). Completing this project study has made me a more confident leader in my classroom and my school. I now regularly read research articles that improve my instructional practice, and I can participate more fully in conversations with colleagues and administrators on topics related to effective instruction and school improvement. I often share articles of interest both with colleagues in my science department and with those who teach in other content areas. This experience has given me the tools needed to contribute to positive change in my school community.

Analysis of Self as Scholar

I have always loved learning and have aspired to be a lifelong learner. Many aspects of the project study process were challenging for me as a learner. I tend to have strong opinions, and I had to learn to take the opinions of my committee members into account without regarding them as harsh criticism. I came to realize that my committee was interested in helping me grow as an educator, researcher, and scholarly writer.

Because my background is in science, specifically biology, I was surprised by the differences between the type of research I have done in the past and social science research. I have done graduate work in entomology and worked as a research assistant in agricultural and environmental laboratories. The IRB approval process was a new experience for me because no one cares what is done to beetles or wheat, my former research subjects. Becoming familiar with all of the participant protection measures required for human research was enlightening and a little frustrating. Considering the abuses that have been allowed in some past research studies, it is comforting to know that such a robust system is now in place to protect human subjects.

By far the most challenging part of the project study process for me was time management. I consistently underestimated the amount of time I would need to complete various components of the study. Sometimes the delays were out of my control, but I found it difficult to carve out the chunks of time needed to get all of the necessary research, reading, and writing done in an efficient manner, and this resulted in many delays of my making. I constantly battled my tendency to be a procrastinator. The good news is that, as the result of the process, I do now consider myself a scholar when it comes to educational research, specifically in the areas of teacher self-efficacy and science instruction.

Analysis of Self as Practitioner

Even though I have more than 20 years of experience teaching secondary science, I continually modify my practice as a result of new information. My research has convinced me of the importance of emphasizing inquiry methods when teaching science, and I have adopted more inquiry based activities in my classroom as a result. My improved knowledge base concerning science instructional strategies has made me a better collaborator and given me the confidence to work cooperatively to share best practices within my department, school, and the greater community.

I now regularly review current literature and strive to keep up with new and innovative ideas for instructional practice. I read articles, through outlets like ASCD Smart Brief, daily and often share those of interest with appropriate colleagues in science as well as in other instructional departments.

Before I started my project study, I was not well informed about local and national achievement gaps. Because the problem that provided the basis for my project focused on achievement gaps, I have become more acutely aware of disparities experienced by students belonging to subgroups. I now carefully monitor student performance to detect any achievement gaps in my classes and provide extra support in the form of tutoring opportunities for affected students. I am also now an active member of the equity team at my school and can make viable suggestions for improving equity because of my research experience.

Analysis of Self as Project Developer

Before my Walden project study, I had some experience designing PD activities. As a College Board endorsed faculty consultant in an advanced placement subject, I have designed and carried out both 1-day training sessions and 4-day summer institutes. The background knowledge in project development provided by this project study, specifically in planning PD activities, would have been invaluable had I had it before all of the PD I previously planned. I now realize that I could have made PD more meaningful and useful for the participants by collecting data to determine their specific needs as part of the planning process. Another modification to make the experiences more useful would be to give the participants some input and choice and to allow more time for collaboration and sharing of best practices between more and less experienced teachers. The experience of developing this project study has improved my ability to plan an effective PD project.

The Project's Potential Effect on Social Change

The lack of sufficient numbers of students pursuing college degrees and careers in science, engineering, and technology fields is a problem for our country. Students who do not experience success in these subject areas early in their schooling are unlikely to accept the challenge of advanced level science courses in secondary school or to pursue these fields when deciding on college majors or careers. Thus, improving the science achievement of elementary school students may help to meet our society’s needs for future scientists and engineers.

There are significant achievement gaps in science between several subgroups and the general student population both locally and nationally. The cost of achievement gaps at both the personal and societal levels is large, resulting in loss of income and opportunity for the lower achieving students, as well as a loss to our national economy (Metz, 2013). The data analysis in Section 2 of this study reveals a significant, positive relationship between teacher inquiry science instruction self-efficacy and the MSA scores of African American, economically disadvantaged, and special education students. The resulting project is a PD program designed to increase teacher self-efficacy, hopefully resulting in an improvement in the science achievement of the students in affected subgroups and a reduction in the achievement gaps currently experienced by these students. If successful, this program could help to reduce the tremendous personal and societal costs of achievement gaps in science.

Implications, Applications, and Directions for Future Research

The results of the research performed as a part of this project study are in agreement with much work found in the current literature: Teacher self-efficacy is strongly related to student achievement. This work is important because it established a significant, positive relationship between teacher inquiry science instruction self-efficacy and student achievement as measured by science MSA scores at the local level. Improving student achievement is a stated goal of the local school system. The results suggested a potential way to achieve this goal by improving teacher self-efficacy through participation in PD.

At the conclusion of the PD activity, teachers will complete a survey to assess the effectiveness of the training concerning increasing the participants' self-efficacy. If this effort is successful, more research needs to be performed to establish whether an increase in teacher self-efficacy translates into increased student achievement in the subsequent school year. This research would be of broad interest because few existing studies have taken this final step of evaluating the effect of increased teacher self-efficacy resulting from PD on subsequent student achievement. Since the baseline data have already been collected as a part of this study, the future research would be fairly straightforward needing only to obtain student scores for the year following the PD experience.

Conclusion

Underachievement in science is a problem in many areas of the United States and in other parts of the world. Many students who fall behind in elementary school are less successful in science throughout their remaining school years. The resulting individual and societal losses are significant since these students are unlikely to pursue college degrees or careers in science and technology. The results of this study support the work previously done by others and suggest one potential solution to this problem. Elementary science teacher inquiry science instructional self-efficacy is positively related to students' scores on standardized science assessments. Providing teachers with the proposed PD experience may increase their self-efficacy and, subsequently, improve the success of their students on the science assessment.

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Appendix A: The Project

AGENDA

Inquiry Science Summer Institute for Fifth-grade Science Teachers

Day 1

I. Welcome and introductions

II. Goals of the Summer Institute PowerPoint presentation explaining the purpose and goals of the professional development institute

III. As a pre-test, the Teaching Science as Inquiry (TSI) instrument to measure science teacher inquiry science instruction self-efficacy will be administered. Teachers who previously completed the survey as part of the research resulting in this program may be excused from this activity.

Lunch

IV. Introduction to an inquiry science activity. Teachers will experience an inquiry based activity first hand by participating in the Mystery Tubes activity.
http://undsci.berkeley.edu/lessons/mystery_tubes.html

V. To provide a way for teachers to distinguish inquiry based instruction from other of science instructional strategies, teachers will perform the Making Tops from Exploratorium Institute on Inquiry.

VI. Time for collaborative discussion and debrief of the day's activities

Day 2

I. Formulating questions and testing hypotheses are the first steps in the inquiry science process. Teachers will practice these skills by participating in the following activity:
Ice Balloons: Exploring the Role of Questioning in Inquiry

Lunch

II. Many science process skills are necessary for success in inquiry science activities. These include observing, questioning, hypothesizing, predicting, planning and investigating, interpreting, and communicating scientific information. Teachers will practice these process skills by participating in the Process Circus Activity.

III. Time for collaborative discussion and debrief of the day's activities

Day 3

I. Inquiry activities are designed to teach science concepts as well as process skills. Teachers will gain insight into how inquiry science lessons achieve both of these goals by participating in the pin and hole experiments activity.

Lunch

II. Teachers need the ability to adapt science activities they may already use to make them more inquiry based. Participating in the parachutes activities will provide teachers with the skills to make such adaptations.

III. Time for collaborative discussion and debrief of the day's activities

Day 4

I. Time to get down to business! Working in teams, teachers will create new activities and modify existing ones. Mentor teachers will assist in this process. The goal will be to leave with at least one inquiry based activity for each instructional unit.

Lunch

Continue morning activity until one hour before the end of the day.

II. The Teaching Science as Inquiry (TSI) instrument will again be administered to evaluate the effectiveness of the program.

III. Wrap up

Detailed Description of Activities

Day 1

Activity 1: Welcome and introductions

Facilitators will be introduced, and the agenda will be distributed. Facilitators will share the background and experience that qualifies them to facilitate training on inquiry science instruction. Participants will be asked to introduce themselves, identify their home schools, and express any thoughts regarding what they hope to gain by attendance at the summer institute.

Activity 2: Goals of the Summer Institute

This PowerPoint presentation will motivate teachers to participate fully and try to gain as much as possible from the professional development institute. Teachers' investment in a professional development program increases with a better understanding of how the training will help them achieve their goal of increasing student achievement (Killion & Roy, 2009). The current state of student achievement on the fifth-grade science assessment will be reviewed and the results of the research study showing a significant positive relationship between teacher self-efficacy and student achievement will be discussed.

Session objectives:

- To establish the need for changing our instruction based on student data and current research.
- To identify the goals of the institute.
- To give an overview of what to expect during the institute.

Agenda:

- PowerPoint presentation
- Discussion and questions

Inquiry Science Summer Institute: Welcome 5th Grade Science Teachers!

Activity 3: Administration of the Teaching Science as Inquiry (TSI) Instrument

Objective: Collect pre-test data

The TSI will be used to measure science teacher self-efficacy with regard to the teaching of science as inquiry. All participants except those who participated in the research study will complete the TSI. This will serve as the pre-test for evaluating program effectiveness. The main goal of the professional development institute is to increase teacher self-efficacy with regard to teaching science as inquiry.

Activity 4: Mystery Tubes

Objective: To introduce an inquiry science activity

The Mystery Tubes activity introduces the nature of scientific inquiry and allows participants to experience an inquiry science activity. They will collaboratively make, test, and modify hypotheses using evidence from observations. A detailed description of the activity can be found at the following website:

http://undsci.berkeley.edu/lessons/mystery_tubes.html

Activity 5: Making Tops

Objective: To distinguish inquiry instruction from other instructional strategies

The Making Tops activity teaches participants to distinguish between inquiry based and other forms of hands on science activities. Teachers first build tops from a cookbook set of instructions and then create tops using their own designs from materials they are supplied. A detailed description of the activity can be found at the following website:

http://www.exploratorium.edu/sites/default/files/pdfs/ifi/Comparing_Approaches.pdf

Activity 6: Closure

Objective: To provide collaboration opportunities

Participants will be given time to ask questions and discuss the day’s activities.

Day 2

Activity 1: Ice Balloons

Objective: To explore the role of questioning in inquiry

Participants will use ice balloons and other materials to generate questions and devise quick explorations to find answers and generate further questions. A detailed description of the activity can be found at the following website:

http://www.exploratorium.edu/sites/default/files/pdfs/ifi/Raising_Questions.pdf

Activity 2: Process Circus

Objective: To practice process skills necessary for successful inquiry science activities.

Using the Process Circus activity, participants will practice using science process skills including observing, questioning, hypothesizing, predicting, planning, investigating, interpreting, and communicating science information. A detailed description of the activity can be found at the following website: https://www.exploratorium.edu/sites/default/files/pdfs/ifi/Process_Skills.pdf

Activity 3: Closure

Objective: To provide collaboration opportunities

Participants will be given time to ask questions and discuss the day's activities

Day 3

Activity 1: Pin and Hole

Objective: To understand how inquiry science activities can teach concepts as well as process skills

By completing the pin and hole activity, participants will be given an example of the power of inquiry science instruction to teach science content. A detailed description of the activity can be found at the following website: http://www.exo.net/~pauld/summer_institute/summer_day3eye_and_brain/pin_and__hole.html

Activity 2: Parachutes Activity

Objective: To practice adapting existing science activities to make them inquiry in nature.

The parachutes activity walks teachers through the process of taking an existing noninquiry science lesson and changing it to be more inquiry based. This activity will then be used in tomorrow's sessions as a template for adapting currently used fifth-grade science lessons to make them more inquiry in nature. A detailed description of the activity is found at the following website:

http://www.exploratorium.edu/ifi-archive/activities/parachutes/parachutesfulltext.html

Activity 3: Closure

Objective: To provide collaboration opportunities

Participants will be given time to ask questions and discuss the day's activities

Day 4

Activity 1: Getting down to Business!

Objective: To create at least one ready to use inquiry based lesson for each fifth-grade science unit of instruction

Working in teams, teachers will adapt existing lessons to make them more inquiry based or, if necessary, create inquiry based lessons from scratch. Teachers will be asked to bring copies of lessons they think are good candidates for adaptation. Facilitators and mentor teachers will be available for answering questions and giving advice.

Activity 2: Administration of the TSI Survey

Objective: To collect post-test data that will be used to evaluate the effectiveness of the professional development program.

All participants will be required to complete the post-test TSI.

Activity 3: Final Wrap Up

Objective: To allow collaboration and closure.

Participants will have time to ask final questions and reflect on what they have learned and what they feel they still need in order to be successful at implementing inquiry based science instruction.

Appendix B: Teaching Science as Inquiry Instrument

Teaching Science as Inquiry
(TSI) Instrument—Inservice Version

Dira-Smolleck, L.A. (2004). The development and validation of an instrument to measure preservice teachers' self-efficacy in regards to the teaching of science as inquiry. Unpublished doctoral dissertation. The Pennsylvania State University.

Teaching Science as Inquiry (TSI-2) Instrument

ID Number: ______________________ **Circle One:** Male Female

Course Title: ______________________ **Circle One:** K 1 2 3 4 5 6

Please indicate the degree to which you agree or disagree with each statement below by circling in the appropriate number as indicated below.

5 = Strongly Agree
4 = Agree
3 = Uncertain
2 = Disagree
1 = Strongly Disagree

When I teach science…					
1. I am able to offer multiple suggestions for creating explanations from data.	5	4	3	2	1
2. I am able to provide students with the opportunity to construct alternative explanations for the same observations.	5	4	3	2	1
3. I am able to encourage my students to independently examine resources in an attempt to connect their explanations to scientific knowledge.	5	4	3	2	1
4. I possess the ability to provide meaningful common experiences from which predictable scientific questions are posed by students.	5	4	3	2	1
5. I have the necessary skills to determine the best manner through which children can obtain scientific evidence.	5	4	3	2	1

6. I require students to defend their newly acquired knowledge during large and/or small group discussions.	5	4	3	2	1
7. My students select among a list of given questions while investigating scientific phenomena.	5	4	3	2	1
8. I provide opportunities through which children obtain evidence from observations and measurements.	5	4	3	2	1
9. I expect my students to make the results of their investigations public.	5	4	3	2	1
10. I am able to provide opportunities for students to become the critical decision makers when evaluating the validity of scientific explanations.	5	4	3	2	1
11. I am able to guide students in asking scientific questions that are meaningful.	5	4	3	2	1
12. I am able to provide opportunities for my students to describe their investigations and findings to others using their evidence to justify explanations and how data was collected.	5	4	3	2	1
13. I create (plan) investigations through which students are expected to gather particular evidence.	5	4	3	2	1
14. I am able to negotiate with students possible connections between/among explanations.	5	4	3	2	1
15. I expect students to independently develop explanations using what they already know about scientifically accepted ideas.	5	4	3	2	1

16. I encompass the ability to encourage students to review and ask questions about the results of other students' work.

5 4 3 2 1

17. I am able to guide students toward appropriate investigations depending on the questions they are attempting to answer. 5 4 3 2 1

18. I am able to create the majority of the scientific questions needed for students to investigate.

5 4 3 2 1

19. I possess the ability to allow students to devise their own problems to investigate.

5 4 3 2 1

20. My students make use of data in order to develop explanations as a result of teacher guidance.

5 4 3 2 1

21. I am able to play the primary role in guiding the identification of scientific questions.

5 4 3 2 1

22. I am able to guide students toward scientifically accepted ideas upon which they can develop more meaningful understandings of science. 5 4 3 2 1

23. I possess the abilities necessary to provide students with the possible connections between scientific knowledge and their explanations. 5 4 3 2 1

24. I expect students to recognize the connections existing between proposed explanations and scientific knowledge.

5 4 3 2 1

25. I expect students to ask scientific questions.

5 4 3 2 1

26. I possess the skills necessary for guiding my students toward explanations that are consistent with experimental and observational evidence.

5 4 3 2 1

27. My students investigate questions I have developed.	5	4	3	2	1
28. My students create scientific explanations based on evidence, as a result of teacher assistance.	5	4	3	2	1
29. My students derive scientific evidence from instructional materials such as a textbook.	5	4	3	2	1
30. I am able to encourage students to gather the appropriate data necessary for answering their questions.	5	4	3	2	1
31. I am able to offer/model approaches for generating explanations from evidence.	5	4	3	2	1
32. I am able to coach students in the clear articulation of explanations.	5	4	3	2	1
33. Through the process of sharing explanations, I am able to provide students with the opportunity to critique explanations and investigation methods.	5	4	3	2	1

34. I require students to create scientific claims based on observational evidence.	5	4	3	2	1
35. I expect my students to think about other reasonable explanations that can be derived from the evidence presented.	5	4	3	2	1
36. I am able to facilitate open-ended, long-term student investigations in an attempt to provide opportunities for students to gather evidence.	5	4	3	2	1
37. I am able to help students refine questions posed by the teacher or instructional materials, so they can experience both interesting and productive investigations.	5	4	3	2	1
38. I am able to provide demonstrations through which students can focus their queries into manageable questions for investigation.	5	4	3	2	1
39. I require students to develop explanations using evidence.	5	4	3	2	1
40. I am able to utilize worksheets as an instructional tool for providing a data set and walking students through the analysis process.	5	4	3	2	1
41. My students refine their explanations using possible connections to scientific knowledge that have been provided.	5	4	3	2	1
42. I am able to model for my students prescribed steps or procedures for communicating scientific results to the class.	5	4	3	2	1
43. I am able to provide my students with possible connections to scientific knowledge through which they can relate their explanations.	5	4	3	2	1
44. I am able to provide my students with evidence to be analyzed.	5	4	3	2	1

45. My students engage in questions I have provided them.
5 4 3 2 1

46. My students engage in questions that are provided by a variety of sources such as the textbook.
5 4 3 2 1

47. My students analyze data that has been supplied, while following teacher instruction.
5 4 3 2 1

48. I expect my students to clarify the questions provided in an attempt to enhance science learning.
5 4 3 2 1

49. I am able to provide my students with the data needed to support an investigation.
5 4 3 2 1

50. My students communicate and justify their explanations to the class using broad guidelines that have been provided.
5 4 3 2 1

51. My students choose the questions they would like to investigate from a list provided.
5 4 3 2 1

52. My students analyze teacher provided data in a particular manner.
5 4 3 2 1

53. My students form their explanations using evidence that has been provided.
5 4 3 2 1

54. I am able to provide my students with all evidence required to form explanations through the use of lecture and textbook readings.
5 4 3 2 1

55. My students construct explanations from evidence using a framework I have provided
5 4 3 2 1

1

56. I expect my students to follow predetermined procedures when justifying their explanations. 5 4 3 2 1

57. My students determine what evidence is most useful for answering scientific question(s). 5 4 3 2 1

58. My students design their own investigations and gather the evidence necessary to answer a particular question. 5 4 3 2 1

59. I expect my students to collaborate with me in an attempt to construct criteria for sharing and critiquing explanations. 5 4 3 2 1

60. My students share and critique explanations while utilizing broad guidelines that have been provided. 5 4 3 2 1

61. I expect students to use internet based resources or other materials to further develop their investigations. 5 4 3 2 1

62. I am able to model for my students the guidelines to be followed when sharing and critiquing explanations. 5 4 3 2 1

63. I am able to instruct students to independently evaluate the consistency between their own explanations and scientifically accepted ideas. 5 4 3 2 1

64. I expect my students to negotiate with me the criteria for sharing and critiquing explanations. 5 4 3 2 1

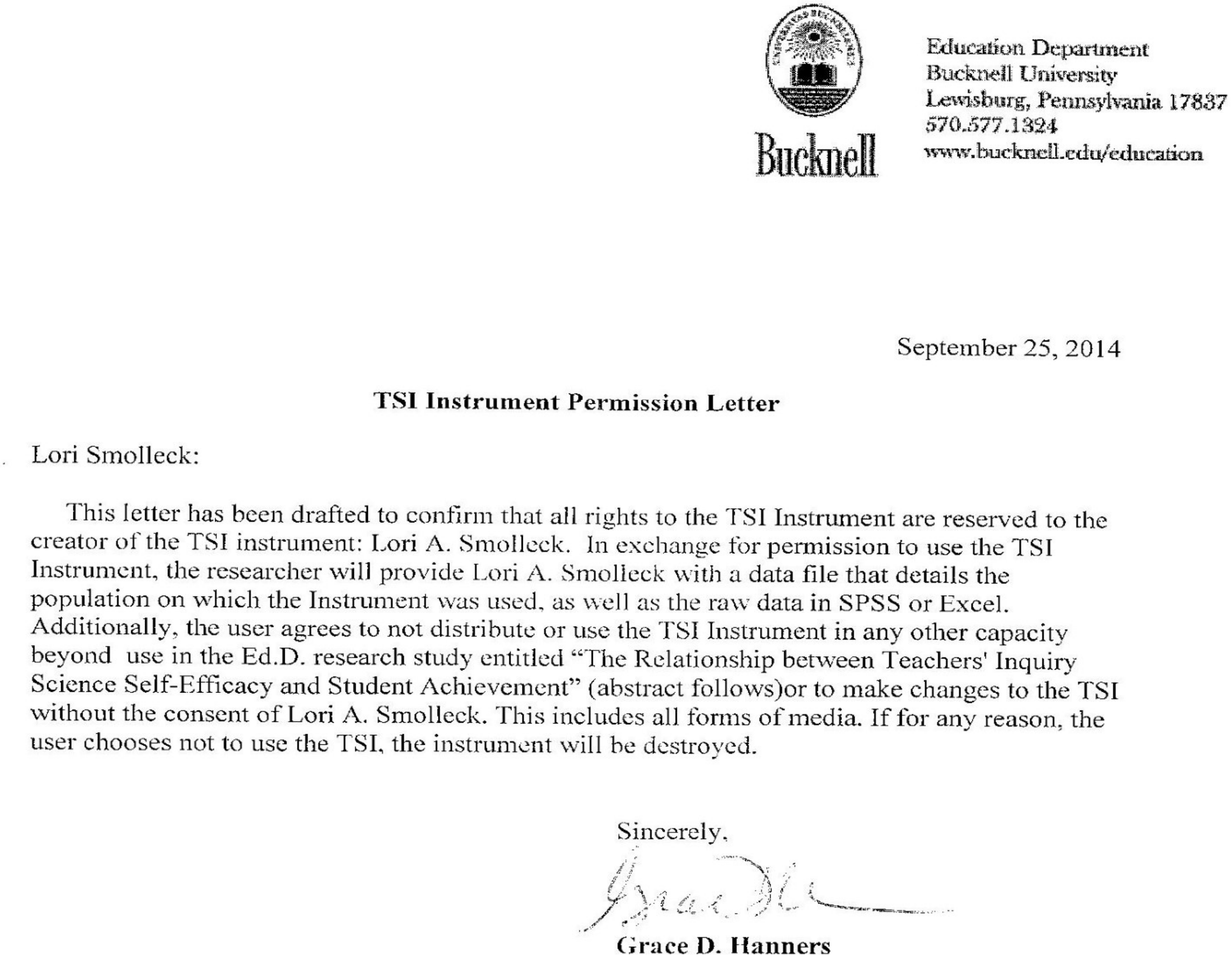
65. I am able to construct with students the guidelines for communicating results and explanations. 5 4 3 2 1

66. I expect my students to refine questions that have been provided. 5 4 3 2 1

67. I am able to provide my students with explanations. 5 4 3 2 1

68. I expect my students to justify explanations using given steps and procedures.	5	4	3	2	1
69. My students comprehend teacher presented explanations.	5	4	3	2	1

Appendix C: Permission to Use the TSI Instrument



Bucknell

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September 25, 2014

TSI Instrument Permission Letter

Lori Smolleck:

This letter has been drafted to confirm that all rights to the TSI Instrument are reserved to the creator of the TSI instrument: Lori A. Smolleck. In exchange for permission to use the TSI Instrument, the researcher will provide Lori A. Smolleck with a data file that details the population on which the Instrument was used, as well as the raw data in SPSS or Excel. Additionally, the user agrees to not distribute or use the TSI Instrument in any other capacity beyond use in the Ed.D. research study entitled "The Relationship between Teachers' Inquiry Science Self-Efficacy and Student Achievement" (abstract follows)or to make changes to the TSI without the consent of Lori A. Smolleck. This includes all forms of media. If for any reason, the user chooses not to use the TSI, the instrument will be destroyed.

Sincerely,

Grace D. Hanners