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Perceptions of elementary teachers from an urban school district in Southern California regarding their inquiry-based science instructional practices, assessment methods, and professional development

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PERCEPTIONS OF ELEMENTARY TEACHERS FROM AN URBAN SCHOOL DISTRICT IN SOUTHERN CALIFORNIA REGARDING THEIR INQUIRY-BASED SCIENCE INSTRUCTIONAL PRACTICES, ASSESSMENT METHODS, AND PROFESSIONAL DEVELOPMENT

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DEDICATION

This dissertation is dedicated to my beautiful wife, Marsha Ugwu and to my children for their sacrifices and support throughout this educational journey.

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ABSTRACT

The purpose of this mixed-methods study was to describe the perceptions of elementary teachers from an urban school district in Southern California regarding their inquiry-based science instructional practices, assessment methods and professional development. The district's inquiry professional development called the California Mathematics and Science Projected, CaMSP lasted for two years.

The CaMSP is a competitive grant awarded by the California Department of Education for the National Science Foundation (NSF) to schools and districts that meet the grant criteria for inquiry-based professional development. This district's professional development model was the five essential features of science inquiry recommended by the National Science Education Standards (NRC, 1996). In 2007, the population of students in this district was 91% Hispanic, 8% African American, and the remainder were of other ethnicities. This district, which is about five miles radius, is located about 15 miles south of downtown Los Angeles.

Twenty two of the 33 teachers, who completed the district's CaMSP project, participated in this dissertation study. The 22 teachers were grades 4 through 6 teachers from 12 elementary schools in the district. The gender make up of these teachers were 10 males and 10 females with experience ranging from 4-20 years.

Data for this study were collected through online surveys (n =22) and face to face structured interviews (n = 10). Results suggested that teachers used questioning, explanations, and experimentation during science instruction. They also used experiment and lab to assess students' science performance. Expert knowledge of the professional developers helped the teachers to understand inquiry-based strategies. Some of these

teachers recommended the inclusion of more district teachers, in future inquiry-based training.

These teachers did not practice inquiry as they would have liked to. The reason for this shortfall included the reduction of science instructional time to increase instructional time for English language arts and mathematics. Other deterrents to science inquiry implementation by these teachers included lack of funding for instructional materials, and lack of support from the school administrators.

Chapter 1: Background

American education is facing challenges associated with science achievement gaps and educational opportunities between students from high socioeconomic status (SES) backgrounds (predominantly White and Asian) and students from low SES backgrounds (predominantly African American and Hispanic). These differences promote disparity in education and income between the two statuses. In order to eradicate these problems, efforts and resources need to be directed toward reducing the income gap by bridging the education gap that exists in our school system (Fullan, 2006). Academic achievement has been skewed in favor of students from high SES as indicated by the National Center Educational Statistics (NCES, 2007a). In the NCES 2007a report for students who scored proficient and above, 81% of White students, 6% of Asian/Pacific Islander students, 7% of Hispanic students, and 4% of Black students scored at or above proficient in science. For students who scored basic and below, there were 32% of White, 3% of Asian/Pacific Islanders, 32% of Hispanic, and 30% of African Americans (Grigg, Lauko, & Brockway, 2006).

Disparity in academic achievement in science has been exacerbated by the advent of the standards movement, advocated by the No Child Left Behind (NCLB) legislation, with its main emphasis on mathematics and English language arts (ELA) (NAEP, 2005). Consequently, efforts and resources in the school systems are mainly directed towards improving mathematics and English language arts proficiency, thus relegating science and other subjects to the background (Griffith, 2008). NCLB is a federal legislation that established a new definition of Adequate Yearly Progress for the state of California, districts, and all public schools, by mandating that 100% of all students score proficient or above in English language arts (ELA) and mathematics by the year 2014 (Mitchell, 2007). According to Mitchell (2007), the state of California modified its accountability system to include Title 1 funding conditions of NCLB, which mandates a minimum percentage of students and numerically significant subgroup that must perform at or above the proficient level on the state testing system.

With the emphasis placed only on English language arts and mathematics in the elementary schools by NCLB, followed by the reduction of science instructional time in favor of these two subjects, the study of science is further diminished (Buczynski & Hansen, 2010), however, the needs for science instruction cannot be over emphasized. We need science in our schools for the following reasons: the production of science literate citizens who would be able to make informed decisions on science related issues in their lives (NRC, 1996), the training of individuals who would be able to make discoveries in various areas of science; materials, energy, medicine and biotechnology, agriculture and astronomy and space (Wilbraham, Staley, Matta, & Waterman, 2002).

The deficiencies in various areas of science including poor science performance of US students in international assessments, disparity in science achievement between various ethnicities (National Center for Education Statistics, NCES, 2007a) and insufficient US trained personnel to occupy available science career openings (McNeill, Lips, Marshall, & Carafano, 2008), call for urgent need for improving science instruction that would potentially help in alleviating these problems. For instance, since the 1990s, the United States has experienced a shortage of scientists and engineers, declining numbers of students choosing these fields as majors, and low student success and retention rates in these disciplines (Willoughby, 2004). There are insufficient mathematics and science teachers in our schools (Mangrubang, 2005). The United States has fallen behind in science achievement both locally, nationally, and internationally when compared with other advanced countries (NCES, 2007a). Also, with the proliferation of science and technology in the modern world, the quality of mathematics and science education in the United States schools is insufficient (U.S. Department of Education, 2000).

To avert these problems, US educational policy on science needs to be reformed in such a way that would encourage the teaching of science at all grade levels in elementary schools infused with effective method of science instruction. Inquiry instruction is one of the reform efforts suggested by some experts in the field of science for science instruction (NRC, 1996). Science inquiry is an approach to science instruction that has the following attributes: experimentation, exploration, questioning, cooperative E OFlearning groups and hands on activities. With this instructional strategy, students' interest in science, attitude towards science, and science engagement could improve and potentially lead to overall increase in science performance (NRC, 1996).

Inquiry-based science is a science reform initiative proposed by the National Research Council (NRC, 1996) and supported by various reform documents like the Benchmarks for Science Literacy (AAAS, 1993) as a promising method of science instruction. The proponents of inquiry-based instruction believe that it would help to curb the multiple problems facing America's science education. The National Science Education Standards (NRC 1996) indicated that science in our schools must be made attainable to all students, irrespective of age, gender, cultural or ethnic background, disabilities, aspirations, or interest and motivation in science.

Inquiry was derived from the root word *inquire* which means to gather information about something or questioning to get an answer to something. Inquiry has two different spellings due to the difference between the English and American spellings, though there is no difference in meaning (Barrow, 2006). According to Barrow (2006), inquiry is sometimes spelled with an *I,* which connotes American spelling, and other times with an *E,* which connotes English spelling. He expressed concern that educators have not reached a consensus as to the operational definition of inquiry. There is a need for science educators to reach a consensus about what is inquiry. This will enable educators to draw a valid conclusion about the implementation of the inquiry process. According to the National Science Education Standards,

> *Inquiry is a multifaceted activity that involves making observations; posing* questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. (NRC, 1996, p. 23)

Other definitions encompass processes, such as using investigative skills; actively seeking answers to questions about specific science concepts; and developing students' ability to engage, explore, consolidate, and assess information (Lederman, 2003). Inquiry can be divided into two types. When it is student-centered or completely driven by students, it is called an open inquiry. When it is teacher guided, it is called a guided inquiry. In guided inquiry, the teacher selects the question and works collaboratively with the students in reaching a consensus on how to research the question, collect, analyze, interpret data and communicate results or findings. Also, students engaging in simple inquiry engage in scientific processes that require active participation and critical thinking. Students engaged in full inquiry use these skills in the context of well-structured, science-subject-matter knowledge and the ability to reason and apply scientific understanding to a variety of problems (NRC, 2000). Inquiry can be used to meet students' academic needs and can potentially help to bridge science achievement gaps that exist in the school system as proposed by the National Research Council (NRC, 1996).

Akerson and Hanuscin (2007) emphasized scientific inquiry and the nature of science within the theme of scientific modeling as a preferred method of science instruction. Their study involved a two week summer workshops and follow up sessions that lasted throughout the school year. Pre and post tests were used in their study to determine teachers' views of the nature of science, inquiry, and scientific modeling. As the study progressed, teachers' views on the nature of science and inquiry improved. At the later part of the study, teachers incorporated scientific modeling in their definition of inquiry as opposed to their earlier definition at the inception of the study that was only knowledge-based.

The National Science Foundation (NSF) was established to fund research projects involving inquiry. During the 1990s (Saks, 2005), k-12 education reform efforts undertaken by NSF employed large scale, systemic approaches to improve science and mathematics learning in elementary and secondary classrooms in the United States. The NSF funding in California is the California Mathematics and Science Partnership (CaMSP) project. It is a grant given to schools or districts who meet the grant criteria to promote the teaching of science or mathematics or both in k-12 education using inquiry. An underlying assumption of the systemic approach employed by the NSF was that student learning outcomes in science and mathematics could be improved through partnerships uniting school districts, university faculty in arts and sciences, and university teacher education programs.

Gallagher (1994) found that the teaching of science using inquiry was helpful in increasing students' interest in science significantly. Learning theorists, educational researchers, and practitioners have proposed that learning environments can be created to bring about a fertile ground for an improvement in the number of students who show interest and excel in science courses. Staver and Wang (2001) found in their study a positive correlation between student science career aspiration and certain factors of science education which included student educational outcomes, instructional quantity, and home environment. Their study explored high school students' transition to the work force. It examined the effect of nine variables; career aspiration, educational productivity, motivation, instructional quantity, instructional quality, home environment, class environment, peer environment and mass media on students' science career choices. They chose science for this study because of its importance in work-preparation and the science reformers believe that science literacy in high school closely will prepare all students to enter the work force. A sound grounding in science strengthens many of the skills people use on the daily bases including solving problems creatively, thinking critically, working with peers, using technology effectively and valuing life-long learning.

The use of inquiry instruction will potentially infuse these qualities on students. Moreover, by the use of inquiry approach, science instruction can be made more meaningful to special education students (Palincsar, Magnusson, Collins, & Cutter, 2001), linguistically and culturally diverse elementary students (Cuevas, Lee, Hart, &

Deaktor, 2005). Inquiry has also been found to be beneficial in deaf education (Mangrubang, 2005).

The district wide inquiry training called the California Mathematics and Science Project, CaMSP was conducted in an urban school district in Southern California. It focused on improving of teachers' content and pedagogical knowledge to improve students' science achievement. The project was a joint partnership between the district and an institution of higher education (IHE) in Southern California. The IHE provided the professional development to the district teachers. The teachers or participants were recruited from the 13 elementary schools in the district. Participation was restricted to grades 4 through 6 teachers only. Three professors from the IHE, one for each grade level or cohort, provided professional development for the participants aimed at improving the teachers' content and pedagogical knowledge for the two years of the project. Out of the 33 teachers, 10 of them were fourth grade teachers, 13 were fifth grade teachers, and the remaining 10 were sixth grade teachers. Each year, the study participants received 60 hours of intensive summer inquiry training on science content and pedagogical knowledge and an additional 30 hours of follow up professional development spread out throughout the school year. The inquiry-based science training in this district lasted from 2008-2009 school year to 2009-2010 school year. The professional development model was the five essential features of science inquiry as described in the National Science Education Standards (NRC, 1996).

Different data collection methods were used including teachers' pre and posttests, students' pre and posttests, structured online survey, classroom observation, and focus group discussions. Data analysis of the teacher pre and posttests showed that there were no significant gains in the teachers' content knowledge. Data analysis of the student pre and posttest showed that there was insignificant gain in students' science achievement.

Statement of the Problem

Inquiry-based training in this district was found to be slightly effective in increasing students' science achievement. This increment was not statistically significantly. Teachers indicated gaining confidence in teaching science as a result of the professional development, which resulted to an increase in their inquiry use. Teachers' classroom observation showed an increase in teachers inquiry use and an increase in students' engagement in science.

It was not known at the sunset of the district wide inquiry training whether these teachers will implement inquiry-based instruction in their classrooms a year or two after later and there was no system structure in place to measure this. Also not known was what will become the assessment methods of these teachers a year or two after the inquiry-based training. The need to find the answers to these questions gave rise to this study.

Purpose of the Study

The purpose of this study was to describe the perceptions of elementary teachers from an urban school district in Southern California regarding their inquiry-based science instructional practices, assessment methods, and professional development. The project scope encompassed grade 4 through grade 6 teachers.

Research Questions

1. How do inquiry-trained elementary teachers in one Southern California district address the five essential features of science inquiry?

2. How do inquiry trained elementary teachers assess students' science performance related to each of the five essential features of inquiry?
3. What types of training experiences are essential to fully prepare elementary teachers to learn and apply inquiry in their classrooms?

Hypotheses

The following nine hypotheses were proposed for this study:

- Hypothesis 1: Inquiry-trained teachers engage learners in scientifically oriented questions.
- Hypothesis 2: Inquiry-trained teachers engage learners to give priority to evidence in responding to questions.
- Hypothesis 3: Learner formulates explanations from evidence
- Hypothesis 4: Inquiry-trained teachers use investigations, research reports projects to access students' science performance.
- Hypothesis 5: Inquiry-trained teachers use constructed response essays to access students' science performance.
- Hypothesis 6: Inquiry-trained teachers use portfolios, journals, lab notebooks to assess students' science performance
- Hypothesis 7: Expert modeling is an effective training experience essential to fully prepare elementary teachers to learn and apply inquiry in their classrooms.
- Hypothesis 8: Peer sharing is an effective training experience required to prepare elementary teachers to learn and apply inquiry in their classrooms.
- Hypothesis 9: Focus group discussion is an effective training experience required to prepare elementary teachers to learn and apply inquiry in their classrooms.

Importance of the Study

This student will be beneficial to the participants, school administrators, local district, other districts and institution of higher learning that provided the professional development.

On the part of the participants, they would be able to learn their instructional practice and assessment methods from this study, and be able to reflect and make modifications in their practice and assessment for improved students' science achievement.

For the school administration, they would be able to learn about the instructional practices of its teachers, and factors that promote or hinder the implementation of inquiry instruction in the elementary classrooms. This would enable the district to take necessary steps required for the successful implementation of inquiry-based instruction.

The local district would also benefit from the factors that promote or inhibit inquiry instructions and be able to determine measures required to ameliorate the situation. The district will also benefit by hearing from the teachers the effective aspects of the professional develop they received. These could be infused by the district in its future professional development trainings.

For other districts embarking on inquiry-based training, this study could be beneficial to them by providing them with the positive and negative factors associated with inquiry implementation which they could use to their advantage. Also they could benefit by deploying the effective aspects of inquiry training delineated in this study.

For the institution of Higher education that provided the training, they will benefit by identifying the effective aspects of the professional development that they could use in their future science method classes and in their future involvements in inquiry trainings.

Also as teachers normally teach the way they were taught, this study will help teachers to overcome their obsolete teaching methods and embrace new and more effective instructional strategies in their classrooms (Brouwer & Korthagen, 2005).

Limitations

The limitations of this study include: teachers missing training sessions, inquiry-trained teachers not using science inquiry in their science instruction, teachers choosing to skip certain questions in the survey instrument, teachers being dishonest in their answers to the survey instrument questions, teachers being dishonest in their answers to the teacher interview questions, and lastly, teachers who received the IBSRT may no longer be in the district as a result of attrition

Delimitations

This study was conducted in one urban school district in Southern California regarding their inquiry-based science instructional practices, assessment methods, and professional development. The project scope was grade 4 through grade 6 teachers.

Assumptions

It was assumed that all the teachers who received the inquiry-based training use inquiry-based instruction in their classrooms, teachers would be honest about the science instructional method they implemented, teachers understood the five essential features of science inquiry, teachers would answer the questions in the teacher survey instrument honestly, teachers would answer the teacher interview questions honestly, and all teachers who received the district CaMSP training (IBSRT) at various grade levels would remain in the same grade levels.

Key Terms and Operational Definitions

Inquiry Method. According to Inquiry and the National Science Education Standards (NRC, 1996), science inquiry instruction enhances students' critical thinking skills, which enables them to respond positively to questions related to science problems. In the process of arriving at the answers to questions, students conduct investigation and control variables. In this study, inquiry refers to student-centered process of teaching, which elicits answers to questions from students and encourages an investigative approach and the techniques scientists use in solving problems as outlined by the National Science Educational Standards (NRC, 1996).

Traditional Method. Chiappetta and Fillman (2007) state that science text books organize the subjects and topics that students should master and explain what students are supposed to learn. This explanation is then transferred by the teacher to the students. According to Chiappetta and Fillman, research has shown that only about 10% of secondary school teachers do not use science textbooks for instruction. In this study, textbook method is used interchangeably with traditional method for the teaching of science.

For the purpose of this study, traditional method of science instruction refers to a teacher centered method of instruction where the teacher does most of the talking, decides what needs to be learned, how to learn it and with a great reliance on the textbooks.

Content Knowledge. This refers to the knowledge of a specific content (Kanter & Konstantopoulos, 2010). For this study, content knowledge will refer to the understanding of specific science content.

Pedagogical Content Knowledge. This is the knowledge of how to make a specific content accessible to others (Kanter & Konstantopoulos, 2010). For this study, pedagogical content knowledge will refer to the ability of a teacher to impact knowledge using the inquiry-based method. Fortified with content and pedagogical knowledge, a teacher will be able to identify a student's misconception in science, diagnose that misconception and come up with a strategy to challenge the student to think of an alternative explanation that will help to correct his or her misconception.

California Mathematics and Science Project (CaMSP). This is a grant funded by the National Science Foundation (NSF) through California Department of education for the promotion of science and mathematics education.

Inquiry-Based Science Readiness Training (IBSRT). This is the title of a California Mathematics and Science Partnership grant in one Southern California public school district.

No Child Left Behind (NCLB). In the United States, responsibility for the education of its citizens lies primarily with the individual states. However, with increasing evidence that many students, particularly minority and poor students, were failing to meet grade level standards and graduation requirements, the federal government felt its role must be increased. The No Child Left Behind legislation was signed into law by President George W. Bush on January 8, 2002. There was overwhelming bipartisan support for this revision of the Elementary and Secondary Education Act of 1965. The legislation put forth a system of accountability measures that promised to reward successful schools and sanction failing schools by the infusion or withdrawal of federal money. Each state had to devise a system of annual assessment where the outcomes were published in School Accountability Reports. Two measures would be used to determine the success or failure of the school, Academic Performance Index (API) and Adequate Yearly Progress (AYP). Academic Performance Index (API) ranks schools based upon how students score on California Standards tests in English, science, mathematics and social studies. The API scale ranges from 200 to 1000 with 1000 being the highest and 200 being the lowest. An API of 800 is considered to be proficient. Adequate Yearly Progress (AYP) is a federal measurement scale that measures schools in four categories: graduation rates, participation on statewide tests, proficiency in language arts and mathematics, and performance in the state accountability program.

Qualitative Study. Qualitative study involves exploring and delineating the meaning individuals or groups ascribe to a social or human problem. This type of research involves emerging questions and procedures and data were collected at the participants' setting. In this process, data were analyzed inductively, from themes that emerge. The researcher interprets the data to the understanding of the readers (Creswell, 2007).

Quantitative Study. Quantitative study is a study that involves the testing of objective theories by examining the relationship among variables. These variables can be measured by using instruments that collect data in numbers that can be analyzed using statistical procedures (Creswell, 2008).

Mixed Methods Study. This is an approach to inquiry that combines or associates both qualitative and quantitative approaches. It involves philosophical assumptions, the use of qualitative and quantitative approaches in data collection that could be collected simultaneously or in tandem, and the mixing of both approaches in a study. This method lends itself to a richer and deeper study compared with quantitative or qualitative study alone (Creswell & Plano Clark, 2007).

Organization of the Dissertation

This dissertation is divided into five chapters. Chapter 1 introduces the background, statement of the problem, purpose of the study, research questions, key terms and operational definitions, nature of intervention, importance of the study, limitations, and assumptions. Chapter 2, which reviewed the literature, contains the historical perspective of science instruction in the United States divided into three areas from the 1950s to 2000. Chapter 2 also discusses methods of science instruction, teacher training, teacher supply, and concludes with a summary of the chapter. Chapter 3 provides a detailed explanation of the methodology used for the study, including the research design and rationale, sampling method and participants, district demographics, human subjects, data collection settings and procedures, instrumentation, and analytical technique. Chapter 4 analyzes the research findings and Chapter 5 discusses the findings and conclusions of the research and proposes policy changes, and makes recommendations for further research.

Chapter 2: Literature Review

Introduction

There are numerous problems facing science education and the potential for achievement in this area in the United States. One major aspect of the problem is the didactic traditional method of science instruction that has led most students to lose interest in science (Lord & Orkwiszewski, 2006). According to Lord and Orkwiszewski (2006), today's students would rather participate in hands-on activity than sit quietly and listen in a class; when that is not the case, they tune out. A second problem concerns the poor performance of U.S. students in local and international assessments when compared with other industrialized nations (Bybee, 2008). Finally, there is a disparity between the science achievements of students from high socioeconomic status (SES) backgrounds (typically White, and Asian/Pacific Islanders) and students from low SES backgrounds, typically African Americans and Hispanics (Bybee, 2008; NRC, 1996). Bridging this achievement gap has been called for by many experts in the field of education. Fullan (2006) specifically called for social justice by advocating processes that would ensure the closure of achievement gaps between different socio economic statuses.

Focus. The focus of this literature review is to explore the historical, theoretical, and empirical literature related to the variables in the study.

Rationale. Reviewing the literature related to science instructional methods, teacher training, and student science achievement is important for four reasons. The first reason is for personal and social well-being. With science knowledge, students will become informed citizens who can make good choices in science related issues in their lives and issues affecting the world. For example, on a personal level, a science-literate person would make informed decisions about his or her lifestyle like whether to smoke or not, knowing the implications of smoking and that it could cause lung cancer. On the global level, science-literate people would make better choices about the preservation of the environment, for instance avoiding environmental pollution and the release of substances like carbon fluorocarbon (CFC) into the atmosphere that has the potential to deplete the ozone layer. Depletion of the ozone layer would expose humans and living organisms to the harmful effects of the sun's ultraviolet rays.

The second reason relates to career quality and success. Training students in science would avail them of the numerous opportunities in science and science-related careers. Some of these careers include materials scientist, analytical chemist, medical laboratory technician, archaeologist, pharmacist, geologist, firefighter, climatologist, solar engineer, wastewater engineer, oncologist, oceanographer, nurse, FDA inspector, microbiologist, mechanical engineer, biochemist and nuclear physician (Wilbraham et al. 2002). In the teaching profession, there is a high demand for science teachers. According to Mangrubang (2005), the turnover rate of science and mathematics teachers is 40% as opposed to the lower 29% attrition rate of all teachers. As a result, there is high demand for science teachers to fill these vacated positions. Also, the United States does not produce enough engineers. Hence there is high demand for engineers to take up the engineering and high tech jobs that has necessitated the importation of foreign engineers (McNeill et al., 2008). McNeill et al. (2008) reported that out of 200,000 engineering jobs available yearly, the United States produces 60,000 annually, which is 30% of the number of engineers needed.

The third reason for reviewing science teaching and learning is related to the need to discover solutions for bridging the science achievement gap between different ethnic student subgroups (White, Asian, African American, and Hispanic). This disparity in science achievement in different U.S. ethnic subgroups is manifested in the results from the Organization for Economic Co-operation and Development (OECD) program for International Student Assessment (Baldi, Jin, Skemer, Green, & Herget, 2007) and other assessment results (Bybee, 2008). There is also a disparity in science achievement between students of high and low SES (Bybee, 2008).

Finally, a fourth compelling reason for research related to the study of science is the high stakes testing in mathematics and English language arts demanded by the No Child Left Behind (NCLB) legislation. This legislation has driven the school administrators' interest in promoting the teaching of mathematics and language arts in elementary schools, while leaving science and other subjects behind. Griffith (2008) conducted a study with 164 elementary school participants using a purposive sampling of K-6 teachers employed in the state of Kansas. The data collection process was through an online survey. In the data collected, 59.1% of the participants indicated that their science instructional time was reduced to increase the instructional time for mathematics and reading in order to increase the schools' Annual Yearly Progress (AYP), as required by NCLB. Annual Yearly Progress is one of the measures used to assess schools and districts in California.

Literature search strategies. Most of the literature reviewed in this chapter was peer reviewed articles. The researcher accessed some databases through Pepperdine University's online library. Some of the databases used for journal retrieval included

Educational Resource Information Center (ERIC), PsycInfo, Education Full Text (Wilson), Google Scholar, and Scopus. Refworks was used for file management and for saving and storing retrieved files. Prior to performing searches using these databases, the researcher identified the main variables for this research as follows: historical perspective of science instruction, methods of science instruction, and student science academic achievement.

Typically, the researcher started most of the research searches in the ERIC database and extended the search to other databases when ERIC failed to yield positive results. In searching for the historical perspective, the researcher typed *history* on the first search field, which resulted in thousands of literature matches. To narrow down this search result, the researcher typed *science instruction* on the second field which gave a result of about 1,500 literary works. To further trim this down, the researcher typed *traditional* on the third field which resulted in about 44 hits. To condense the list further, the researcher selected *peer reviewed*, which brought it down to a manageable number of about 10 articles. This process retrieved information for the historical perspective of science instruction using the *traditional* method. For the historical perspective of the inquiry method, the same process was repeated but with a slight variation of replacing the search word traditional with inquiry. A similar process was used to retrieve journals for the rest of the research study variables.

Overview of the organization of the literature review. This dissertation literature review is organized into three main sections: a historical perspective of science instruction in the United States, a review of two principal methods of science instruction, and academic achievement of students in the United States.

Historical Perspective of Science Instruction in the United States

Two major studies will be discussed under this heading. One study is Kelly and Staver (2004), "A Case Study of One School System's Adoption and Implementation of an Elementary Science Program." The other study is Sandall (2003), "Elementary Science: Where are we now?" These studies will be discussed for the following time periods: 1950s and 1960s; 1970s and 1980s; and 1990s and 2000s.

According to Kelly and Staver (2004), the history of science instruction reform in the United States over the last 60 years mainly consists of two contrasting approaches and a steady swinging back and forth between the two like the oscillation of a simple pendulum. On one end, is the teacher-directed traditional method of science instruction and on the other end is the student-centered science inquiry method. Kelly and Staver highlighted how the methods of science instruction have changed over the last 60 years and some of the factors associated with these changes.

In the second study, Sandall (2003) chronicled the historical perspective of elementary science education from 1960-1999. Sandall's study was divided into two parts: the first part focused on the historical perspective of science instruction in the 1970s; the second part focused on the historical perspective of science instruction in the late 1990s. Sandall discussed the importance of standards as a vehicle for effective instruction and assessment, including the problems associated with creating national standards regarding what to cover, purpose and nature of the standard, and how the standard will be constructed without bias towards any specific group of students.

1950s and 1960s. In the study by Kelly and Staver (2004), there were two diametrically opposed views about science instruction in the U.S. schools. On one side was the group who contended that science instruction should only be for those students who were doing well in science in the schools. This group favored a traditional method of science instruction. On the other side was the group whose position was that science instruction should be for all students. This group favored the inquiry method of science instruction. Kelly & Staver labeled the proponents of the traditional method as the *professionalists* and the proponents of the inquiry method as the *visionaries*. According to Kelly & Staver, the professionalists believed that the purpose of science education was to prepare students who would pursue science or science related careers in the future. The professionalists also contended that science education is for a select few, and hence supported making science available to only those few students who excelled in science, without investing in efforts to motivate and encourage students who struggled.

On the contrary, the visionaries believed in science literacy for all Americans. The visionaries believed that by being science literate, students are not only prepared to excel in science and science related careers, but are also prepared to become good and enlightened citizens. Kelly and Staver (2004) went further to review available literature on the state of science instruction from 1950 to 2004 and discovered that traditional science instruction has dominance over inquiry method, although they indicated that teachers are gradually adopting new teaching practices that are different from the traditional approach. One of the catalysts that brought about this shift was the launching of Sputnik in 1957.

Prior to this time, the views of the professionals dominated science curriculum development in the U.S. schools because of the apparent neglect of science instruction by the schools and teachers. The curriculum focus at that period was on traditional textbook method of science instruction. After the launching of the Sputnik, the pendulum swung in favor of the visionaries' view of inquiry instruction (Barrow, 2006; Kelly & Staver, 2004; Pine et al., 2006). The advances made by the Russians in science aroused the interest of the United States in science education and the nation saw the urgency to have its youths excel in science in order to have a competitive edge against Russia in space exploration.

The American Association for the Advancement of Science (AAAS, 1990), *Benchmark for Science Literacy* (AAAS, 1993), and the *National Science Education Standards* (NRC, 1996) are publications that spoke in favor of science for all Americans. The views expressed in these publications are consistent with that of the visionaries. As a result of the broad discussion that ensued during this period of time, which involved diametrically opposed view points for science instruction, the nation saw the urgent need to embrace the view of the visionaries-science for all Americans. It was believed that this would help the United States catch up to, and even surpass, Russia's breakthrough in space exploration and place the United States in the forefront of science and technological advancement; however, according to Kelly and Staver (2004), the professionalists' view dominated curriculum development in the 1950s and 1960s in the United States.

During this period, the National Science Foundation was born. The National Science Foundation (NSF) was created in 1950 by the National Science Foundation Act. NSF is an autonomous federal agency whose responsibilities include sponsorship of projects and research to enhance advancement of science and science related fields including mathematics and technology. The idea of what to do with the technological advances made in World War II fueled its formation. In 1944, as victory in World War II was imminent, President Roosevelt asked scientists to think of ways to utilize wartime science and technological advances to benefit human kind after the war. The search for an answer to this question led to the birth of the NSF. Ultimately, the goal of NSF was to position the United States at the forefront of global research and innovation. NSF is entrusted with federal fund allocation for the sponsorship of research and projects to enhance science and engineering in the nation.

Some of the early secondary schools' projects awarded by the NSF included the integrated biology, chemistry, and physics course prepared by the Portland Project Committee of Oregon in the 1967-1968 academic year (Scott, Dittmer, & Fiasca, 1967) In selecting materials for their project, the Portland Project committee, reviewed and selected material developed by the national course improvement groups−Physical Science Study Committee, Chemical Bond Approach, Chemical Education Materials Study, Biological Science Curriculum Study and Introductory Physical Science, and also added material written specifically for the project. For the Portland Project, each exercise that students were required to master was revised until 90% of the students scored a mean score of 90%. The Science Curriculum Improvement Study was conducted at the University of California, Berkeley. The project was the innovation of Dr. Robert Karplus, a physics professor at Laboratories at Berkeley (Kratochvil & Crawford, 1971)

Also, elementary schools benefited in the early NSF sponsored projects. Some of the elementary science reform projects were Elementary Science Study (ESS), Science-A Process Approach (S-APA), Science Curriculum Improvement Study (SCIS), and Conceptually Oriented Program in Elementary Science, COPES (Kyle, Shymansky, & Alport,1982). ESS was developed by Education Development Center, Inc., a private nonprofit organization in Cambridge, Massachusetts. ESS is an elementary school science program that began in small scale in 1960. S-APA is a project for kindergarten through grade 6 that was sponsored by American Association for the Advancement of Science (AAAS). Teams of scientists and educators developed the AAAS programs for science education.

Sandall (2003) invoked responses of teachers from different districts. Answers were sought from these teachers on the criteria used to select their science curriculum materials. Sandall's study began after the controversial Project Synthesis. Project Synthesis was a report on the state of science education in the 1970s resulting from data collected from four different projects. In 1960, curriculum was uniform and based on two assumptions (Sandall, 2003). One of these assumptions was that the presentation of science topics as done by scientists would be interesting to students. The second assumption was that no matter the stage of development, a child would be receptive to any subject taught. This view is contrary to the theories about cognitive development attributed to the work of Jean Piaget from 1896 to 1980. Sandall also found that if not for the scarcity of materials, educators welcomed the idea of using inquiry instruction as proposed by the National Science Educational Standards (NRC, 1996). The second part of Sandall's research was on the state of science education in 1999, which will be discussed under "1990s and 2000s" era of this literature review.

1970s and 1980s. In the 1970s and 1980s, NSF continued funding different science projects. In the 1970s, NSF funded a new science curriculum project for the state of California and Nevada, awarded to Far West Lab, in Berkeley, California. Far West Lab then developed a science curriculum and trained public school teachers on how to implement the curriculum in their classrooms. This curriculum project emphasized the inquiry method.

According to Kelly & Staver (2004), around the mid-1970s, the curriculum progress made in the perspective of the visionaries was shattered by six main problems: schools did not give priority to science instruction; there was inadequate teacher preparation and administrative support; there were no dramatic results produced as a result of the visionary perspective; there was no sustainability and institutionalization of the visionaries' advances made; there was a lack of enthusiasm by the school administration and schools to maintain inquiry instruction; and finally cosmetic rather than sustainable changes were made in favor of inquiry instruction. These deficiencies led the science instructional approach pendulum to swing in the direction of the professionalists' perspective during this period.

The National Commission on Excellence in Education (1983) released a report "A Nation at Risk." This report delineated the state of education in the country following the abysmal performance of U.S. students in international assessments. The report's findings on problems facing science education included: insufficient physics, mathematics, and chemistry teachers at the secondary level; lack of highly qualified teachers in science and mathematics classrooms in secondary schools; professional development need for the few highly qualified science and mathematics teachers at the secondary schools; and need for reform of science and mathematics curriculum to meet the needs of the students. As a result of the national discussion that ensued after the release of "A Nation at Risk," a broad range of reform in science and mathematics took place (Richardson & Liang, 2008).

One of these reforms was that institutions of higher learning responded by re-examining and modifying how they educated teachers. Another reform was that the K-12 educators responded by re-examining and modifying their curriculum and standards. In terms of standards, one of the questions looming then was whether or not the national educational standards should emphasize a wide range of topics without depth or a few science topics studied in depth. This was important because the United States schools covered more topics than other developed countries that outperformed the United States in international assessments. The national response to “A Nation at Risk” coupled with the government support, led to the promulgation of Goal 2000: Educate America Act. One of its tenets was that the country would be the best in science and mathematics in the world by 2000.

Sandall (2003) posited that in the 1970s, curriculum shifted to diversity of goals, philosophies, and types of materials. According to Sandall, the programs of the 1970s varied in student outcomes, learning and teaching styles, cost, format, and content. In the 1980s, the intent of science education was scientific and technological literacy (Staver & Bay, 1987). In an effort to reach this goal, the NSF engaged in the development of new instructional materials (Harms & Yager, 1981). Harms and Yager (1981) analyzed three different data sources from the projects funded by the NSF and one data source funded by the Office of Education. These four studies, which later became the backbone of Project Synthesis, provided comprehensive information about science education in the country. According to Buczynski and Hansen (2010), several waves of teaching reforms have taken place in the last 40 years. They stated that all of these reform movements have emphasized the need to embrace the teaching of science using inquiry. Joseph Schwab proposed the concept of inquiry in 1965. He posited that science inquiry mirrors the steps utilized by real scientists in conducting their investigations (Wallace & Kang, 2004). Ever since Schwab's statement, the nation has paid more attention to inquiry instruction with the National Science Education Standards supporting the adoption of inquiry as the alternative method of science instruction.

1990s and 2000s. According to Kelly and Staver (2004), the visionaries perspective prevailed in this era with the release of the following reform documents: Science for All Americans by the American Association for the Advancement of Science (AAAS, 1990), *Benchmarks for Science Literacy* (AAAS, 1993), and the National Science Education Standards (NRC, 1996). Project 2061 started in 1985 with the sighting of Halley's Comet. Children who started school in 1985 will see the return of the comet in the year 2061 (76 years later). Those who started Project 2061 were concerned with the degree of scientific and technological advances that the nation would undergo from 1985 to 2061. Project 2061 is composed of a panel of expert scientists, mathematicians, and technologists who sorted out the level of scientific knowledge required for the next generation to become science literate. The panel's recommendations were released and published in Science for All Americans (AAAS, 1990). The publication emphasized that science education should help students to develop the habits of mind, critical thinking, and analytical skills needed to succeed as human beings and also the ability to work collaboratively with others in solving world problems. In other words, AAAS emphasizes the use of inquiry instruction in our schools. To further this view, *Benchmarks for Science Literacy* (AAAS, 1993) was published by Project 2061 to delineate what every American student should be able to learn and do in science, mathematics, and technology at different grades levels by the time they complete high school. It outlined the standards expected to be covered at each grade level in the K-12 educational system. The *Benchmarks for Science Literacy* was instrumental in the formation of the National Science Education Standards and Improvement Council.

After the publication of American Association for the Advancement of Science, came another publication, the National Science Education Standards (NSES) by the National Research Council (NRC, 1996). In an effort to determine the scope of science knowledge that merits science literacy, NSES proposed the implementation of science inquiry in the schools. NSES discussed the Organization of the Standards, Science Teaching Standards, Professional Development Standards, Assessment Standards, Science Content Standards, Science Education Program Standards, and Science Education System Standards (NRC, 1996).

Moreover, the John Glenn commission was formed in 1999 to study and report on the quality of mathematics and science teaching in the country as a result of the dismal performance of U.S. students in international assessments. The commission, formed by the National Commission on Mathematics and Science Teaching came developed a document entitled Before It Is Too Late. The Commission found it astonishing that the schools were still using methods of mathematics and science instruction used two generations ago. The Commission called for a new reformed, systemic, and effective method of mathematics and science instruction. In its recommendation, the Commission called for the nation's schools to embrace high quality teaching through inquiry (U.S. Department of Education, 2000).

On the second part of her research, Sandall (2003) worked with a group of teachers in delineating a comprehensive science curriculum from the national standards, state standards, district goals, and the needs of the learner and community. She addressed how curriculum can be selected to meet these needs. Sandall's study was designed to accomplish the following: introduce teachers to the National Science Education Standards and Illinois Learning Standards, identify school goals and needs and apply the National Science Standards, Illinois Learning Standards, and local school goals in creating an effective curriculum. This second research project was a larger study conducted with teachers from various school districts. In a need assessment survey created to elicit the criteria used to select curriculum materials by these teachers' districts, most of them indicated the use of a curriculum selection committee. The selection of these committees members was vetted by faculty members. In the survey, three quarters of the participants indicated that their district utilized national and state standards in their curriculum material selection process. The participants found out that most of the curricula were outdated and most of the schools discovered that their curriculum did not align with all of the standards.

Methods of Science Instruction and Teacher Training, and Teacher Supply

This section discusses the traditional and inquiry methods of science instruction including the barriers associated with the effective implementation of inquiry instruction and how to overcome these barriers. It also discusses teacher training and teacher supply and the need for systemic and continuous professional development for new and veteran teachers. It further suggests measures to curb the shortages of science and mathematics teachers.

Traditional method. In their study about whether teacher education makes sense with regards to teachers' practice, Brouwer and Korthagen (2005) found out that the impact of teacher training on teacher practice is small. According to Bouwer and Korthagen, teachers normally teach the way they were taught. Teachers, they opined, often imitate their prior K-12 teachers. Some other researchers attribute non implementation of professional development learning to teachers' low confidence (Dietz, & Davis, 2009; Girod & Twyman, 2009). An instance of where low confidence can manifest is in elementary school teachers who teach all subjects and do not have sufficient science background consequently; they do not feel confident teaching science due to lack of subject matter knowledge (Dietz & Davis, 2009). When they do teach science, they assign students pages to read in their science textbook and worksheet to complete afterwards.

These teachers have the assumption that their students read and comprehend at their grade levels; however, this is not always the case. In 1995, the National Assessment of Educational Progress (NAEP) found that only 44% of the nation's fourth-graders could read fluently (Abadiano & Turner, 2005). Occasionally during science instructional time, educators who lack science content knowledge write page numbers from science textbook on the board for students to read followed by questions to answer after reading without effort to introduce and explain the topic. Some educators may also require their students to complete pages from their workbooks after reading the textbook.

Comprehension is the main purpose of reading a text. However, science text books found in elementary classrooms are difficult for many students to comprehend because a different skill set is required to understand and interpret expository text

(Nolasco, 2009). According to Nolasco (2009), the poor comprehension skills of students result in poor performance on standardized tests that are designed to assess student comprehension, among other things. She posited that to better prepare science students for high stake tests, educators should help them understand how information inside an expository text is organized and how the concepts relate to one another. The study suggested the use of literature circles in science, which is a strategy frequently used with fictional literature in language arts classes. It involves discussions and explanations of ideas by students in groups that help to deepen the comprehension of all students while communicating amongst themselves, asking questions, and exchanging ideas. This process is similar to the aspects of science inquiry that involves discussion and justification of answers to questions.

Despite calls for science instruction reform since the launching of Sputnik by the Russians in 1957 (Barrow, 2006; Kelly & Staver, 2004; Pine et al., 2006), most science teachers have maintained the traditional method of science instruction. This is surprisingly true even for new science teachers whose teacher education programs have emphasized reform-based instruction in their teaching method classes. In order to understand how reform-based teaching can be done by new teachers, there is a strong consensus among scholars that teachers' beliefs and self-efficacy about the nature of science are important in science education today (Liang & Richard, 2009; Naizer, Bell, West, & Chambers, 2003).

Bandura first used the term *self-efficacy* in the late 1970s. According to Bandura, (1977), perceived self-efficacy is a person's belief that one possesses the ability of high performance required to accomplish a given task that exercises influence over his or her life. He suggested that how teachers perceive their efficiency affect the learning environments. According to Wallace and Kang (2004), teachers' beliefs can impact teaching and learning in two ways. First, they influence teachers' actions and second, they influence students' beliefs and students' actions.

Another belief construct, teaching outcome expectancy, is the belief that teaching will affect students learning (Ashton & Webb, 1986). Bikkar, Beamer, and Lundberg (1993) found a relationship between self-efficacy, teacher performance, and student achievement. It has been shown that teachers with high self-efficacy have higher expectations from their students and are more committed to ensuring an increase in students' knowledge. Enochs, Scharmann, and Riggs (1995) showed in their study that the higher the confidence of teachers in their instructions, the higher the probability of choosing activity-based instruction in the classroom.

Teaching outcome expectancy refers to teachers' belief that specific teaching methodologies will influence students' learning. One factor attributed to non-implementation of new instructional strategy is the demand of the new techniques on the teachers. Such demand can be curbed by having professional development for teachers. It has been found that the piecemeal nature of professional development given to teachers is also a barrier to new program implementation (Guskey, 2000). Professional development should be a continuous program, carefully planned to support teachers both outside and inside their classrooms.

Another issue associated with non-implementation of a new instructional strategy is the lack of materials due to financial constraint. Fund availability is an essential ingredient that would enhance the procurement of the necessary materials for the successful implementation of a new strategy. Availability of all the materials would motivate teachers to practice and improve their pedagogical content knowledge. Improving teachers' pedagogical content knowledge through a carefully and thoughtfully planned professional development and supply of instructional materials coupled with time to reflect on their practices would contribute in raising teachers' confidence in implementing new instructional strategy. Professional development experts have reiterated the need for constant follow up with teachers in their classrooms to reinforce the knowledge, understanding and skills acquired from the professional development.

Inquiry method. The scientific community, including the American Association for the Advancement of Science (AAAS), National Academy of Sciences (NAS), National Science Foundation (NSF), and American Physical Society (APS), has played a role in science education reform in American schools (Lopez & Schultz, 2001). Lopez and Schultz (2001) indicated that the launching of the Sputnik, the first successful space exploration by Russia, gave rise to the renewal of United States interest in science. This renewed interest resulted in the promotion and production of more scientists and engineers and also led to an increase in the attention given to grades K-12 science education in the United States. These concerted efforts deepened the study of science and gave the United States a competitive edge in the race for space exploration. The United States made efforts to reinvigorate students' education in science and to develop student interest in science so that students would be able to successfully pursue science careers and science related careers. Job opportunities were created in science and technologies to help advance the US, in these fields that would help it not only to catch up with Russia but also to surpass it in the areas of technology and space exploration.

Another factor that has brought about an increased interest in science is that the United States has realized that most problems facing the world, such as global warming, acid rain, pollution, and diseases, to mention but a few, are of a scientific nature. Hence there is a call for all Americans to become scientifically literate. This perspective as opposed to science for the best and the brightest proposed by some people in the scientific community led to a heightened call for the systemic reform of K-12 science education with most people advocating using inquiry instruction where students are actively involved in science through investigation.

Inquiry instruction is consistent with how real scientists do or practice science. For a sustainable inquiry instruction implementation, Lopez and Schultz (2001) stated that the following conditions must exist: schools need to design an alternative method of assessing inquiry instruction, different from the current fact-based, standardized test, aligning assessment with goals and objective of the instruction; all stakeholders must be notified of the new method of assessment and they should all participate in this reform efforts.

The idea of science inquiry that calls for students to engage in practicing science, instead of memorizing science facts, was slow in gaining momentum. Despite the fact that scientific research has been based on inquiry since Galileo rolled balls down ramps in the 17th century (an experimental investigation to answer questions about the natural world), it was only in the mid-19th century that science became part of the school curriculum (Pine et al., 2006). In elementary schools, a majority of the teachers used hands-on activities, contrary to secondary schools where rote memory dominated. Rote memory has been known to diminish students’ interest in science. For instance, while reflecting on his education, Einstein was baffled that the traditional method of science instruction did not erase the natural desire of inquiry in all humans.

In the later part of the 19th century, some eminent scientists advocated for science to be taught through students' experiences. This was a challenge because teachers normally teach the way they were taught during their high school years (Brouwer & Korthagen, 2005). In 1902, John Dewey gave his support to inquiry-based science education. In spite of these supports, inquiry based instruction remained dormant in the first half of the 20th century.

The attention given to inquiry instruction began to change in 1957 after Sputnik. Then, public and political interest in strengthening America's science and technology education piqued. The NSF which was founded to improve science and mathematics education went into action. The NSF funded high school science curriculum projects led by scientists in physics, chemistry and biology. One of these projects was the Physical Science Study Committee (PSSC). After the formation of the high school Physical Science Study Committee (PSSC), physics curriculum was developed. Thereafter, the authors saw the need to start inquiry-based instruction at the elementary level, which led to this method of instruction at the elementary level (Kelly & Staver, 2004).

Some of these early projects included the elementary Science Study (ESS), which sprang up in 1961 (Pine et al., 2006). Also, two other projects for elementary curricula were developed by a teacher-scientist alliance (TSA), the Science Curriculum Improvement Study (SCIS) and Science, a Process Approach (S-APA). All three projects focused on active student participation in learning science through investigations. The NSF reported in 1977 that 32% of public school districts had embraced inquiry-based curricula. Numerous studies were carried out to verify the authenticity of these curricula (Bredderman, 1983; Cuevas et al., 2005; Dickerson, Clark, Dawkins, & Horne, 2006; Houston, Fraser, & Ledbetter, 2008; Pine et al., 2006; Ruiz-Primo, Tsai, & Schneider, 2010). In one of these studies, Bredderman (1983) stated that inquiry based science can improve science achievement, science process, and innovation. In addition, he asserted that inquiry can increase conceptual understanding by 10-20%.

However, despite the evidence of the inquiry success, the use of these curricula was not widely practiced as only a handful of districts implemented it (Pine et al., 2006). Despite this deficiency, in 1990, NSF created new K-6 inquiry-based curricula that focused on student centered instruction. These new curricula were similar to those of the 1960s with some modifications. They were developed by science educators and were improved editions of the earlier versions to enhance their user friendliness. These curricula were Insights, Full Option Science System (FOSS), and Science and Technology for Children (STC). They were created to cover about 6-8 weeks of science instruction in a school year (Pine et al., 2006). Each unit dealt exhaustively with topics on physical, biological, or earth science. These curricula were embraced by some districts that have storage centers for housing the instructional materials. Some researchers have shown that the use of FOSS-based kits improves the achievement of English language learners (Cuevas et al., 2005). Also, FOSS-based kits have been found to be beneficial to students with learning disabilities (Palincsar et al., 2001). A positive correlation has also been found to exist between FOSS-based kits and deaf education (Mangrubang, 2004).

Teacher training. Following the release of “A Nation at Risk” in 1983 was the study conducted by Blank and Engler (1992). In their study, Blank and Engler set out to verify three things: (a) whether or not students started receiving more instruction in science than they did before “A Nation at Risk” report was released, (b) whether or not the supply of qualified science and mathematics teachers improved after “A Nation at Risk” report had been released, (c) whether or not students started learning more science and mathematics after the release. The results of Blank’s and Engler’s findings indicated that the enrollment of students in science and mathematics courses in high school at all levels increased as a result of state policies to combat the deficiencies contained in “A Nation at Risk” document. The data from this study stated that some states made more significant progress than others in encouraging more students to pursue study in science and mathematics. On the supply of qualified teachers, they found that although many of the state policy initiatives were aimed at improving the supply and quality of teachers, nationally the shortage of mathematics and science teachers remained. Currently, there are still shortages of science and mathematics teachers in our schools (Mangrubang, 2005). This shortage is partly attributable to the lower teachers’ salaries compared with the salaries of science graduates in other professions. Consequently, science graduates are attracted more to other professions than to teaching.

With the abysmal performance of United States students in science in the global arena compared with the other developed countries (National Science Board (NSB), 2004), there was a clarion call for a science education reform that would improve science achievement (NRC, 1996). For instance, California’s science performance is the worst in the country, yet it employs the highest number of high tech personnel (NCES, 2000, 2006). This call for reform was echoed by the publication of the National Education standards (NRC, 1996), which highlighted the type of instructional reforms needed to improve the quality of science instruction and students' science achievement. Inquiry-based, student-centered reform was at the forefront of this publication's recommendations. For teachers to learn how to implement this new strategy, professional development is crucial.

An instance of such professional development was the one conducted by Buczynski and Hansen (2010). They conducted a study on teacher professional development centered on teacher practice. This study involved a partnership between an institution of higher learning, a science center, and two school districts in an urban area to offer particular science content and process techniques to grades four through six teachers using the inquiry-based instruction. The study focus included the improvement of students' mathematics and science achievement, improvement of teacher content and process knowledge, and the improvement of the study of mathematics and science in the schools involved. One hundred and eighteen (118) experienced teachers were involved in this study with a corresponding 30,434 students. University professors provided the professional development. The study used standards-based content and inquiry-based strategies to improve science teachers' instruction by providing them rigorous mathematics and science training. Data collection comprised pre-professional development focus groups, pre and post subject matter tests, teacher survey, classroom observations, and students' achievement scores. Results of this study showed that the content and pedagogical knowledge of teachers involved in the program improved. However the improvement in students' science achievement was minimal.

In an article by Buczynski and Hansen (2010), they provided several impediments to the implementation of the knowledge gained from the professional development. One barrier involved the insufficient time allotted for science instruction by school sites/districts. Science instructional time was reduced and English and mathematics time increased to enable schools meet their AYP requirement demanded by the No Child Left Behind (NCLB). Another barrier was a school and district requirement for all teachers including project teachers to teach mandated curriculum. Yet one more barrier identified in this study was language learning. It is predicted that by 2030, two fifths of school age populations will be English language learners (Rosebery & Warren, 2008). This will further increase the problems teachers have to reach the science educational needs of the underserved student population. Another barrier found in the study of Buczynski and Hansen regarding professional development implementation was the lack of resources, which was the most pressing barrier that hindered the implementation of knowledge gained in the professional development. Teachers complained about the cost of doing science. The final issue that came up as a hindrance to professional development implementation in this study was classroom management. Sometimes, students had difficulty in utilizing appropriately the freedoms entailed in inquiry instruction. During classroom observation, the authors observed that some students did not use their time appropriately. Some students were involved in other activities besides inquiry because they were not familiar with the self-directed learning approach embedded in inquiry instruction.

In another study, Cuevas et al. (2005) studied teachers' perspectives on enhancing English language learners' science instruction by training science teachers. This was a 5 year professional development intervention program aimed at promoting elementary teachers' knowledge, beliefs, and practices in science instruction. The intervention included instructional materials and teacher training that boosted science learning of all students including English language learners (ELL). The participants in this study included grades 3, 4 and 5 teachers and their students in seven elementary schools in a large urban school district. In the first year of its implementation, the program had 44 third grade teachers and their students. In the evaluation of the professional development, the treatment teachers rated the intervention, the program, and how the intervention affected science teaching and learning as effective.

The teachers' opinions were sought on the three areas of strengths and the three areas of weaknesses of the study. On the three areas of strengths, the teachers indicated that (a) the availability of instructional materials made their work stress free, (b) students were able to work with various materials, and (c) the teacher instructional guide was useful and user friendly. On the three areas of weaknesses that need improvement teachers comments were (a) the need to improve the booklet provided to students; Some teachers were dissatisfied with the unbound nature of the students' booklet, (b) that there was a need to incorporate more experiments into teacher workshops and to encourage more collaboration and collegiality between teachers of participating schools and (c) they suggested matching the teachers' guide with the page numbers of the students' workbook.

The goal of the Cuevas et al. (2005) investigation, *Professional Development in Inquiry-Based Science for Elementary Teachers of Diverse Student Groups*, was to study teachers' initial beliefs and practices about inquiry-based science and to investigate if teacher training intervention using instructional units would effect a change in teachers' beliefs and practices regarding inquiry. This investigation found that teachers reported improved science content knowledge and improved beliefs about science with diverse student groups, but conversely, the implementation did not reflect the stated beliefs. The data sources for this study were focus group interviews, a questionnaire, and classroom observations.

In another study on teaching and learning about inquiry, Wee, Shepardson, Fast, & Harbor (2007) used a qualitative study to investigate if teachers understand and implement inquiry in their classrooms. Wee et al. wanted to find out if teachers implement inquiry instructional strategies in their classrooms after inquiry professional development. The study evaluated teacher knowledge and implementation and found out the following: there was no significant change in an individual teacher’s inquiry process knowledge; though the teachers learned the process of inquiry in teacher training, the implementation was rarely carried out in their classrooms. There were 13 participants (5 males and 8 females) in this study and four data sources were used. The findings showed that (a) teachers’ individual understanding of inquiry was not improved by classroom inquiry implementation, and (b) teachers’ implementation of inquiry did not reflect their ability to design inquiry lessons nor did it show a mastery of inquiry in the context of classroom instruction.

The lack of continuous support after initial professional development programs has been suggested as one of the possible reasons that teachers who receive training on inquiry instruction strategy fail to exhibit high levels of inquiry instruction implementation in their classrooms. Experts have suggested continuous professional development and follow up sessions as a panacea for sustainable inquiry-based practices.

Supply of highly qualified science teachers. The high attrition rate of teachers, especially science and mathematics teachers, has exacerbated the problem associated with providing rich and uninterrupted science instruction and achievement in the schools. High teacher turn over brings with it the issue of new teachers without experience (Wood & Stanulis, 2009). Wood and Stanulis (2009) recommended quality induction for new teachers that would include a wide variety of mentoring, professional development and formative assessments. Formative assessments would help to identify teachers' areas of need so that appropriate intervention measures could be deployed. The demand for science teachers has been on the rise with the high attrition rate of science teachers (Mangrubang, 2005) and the population increase of school age children (NCES, 2010).

The National Center for Educational Statistics (NCES, 2007b) reported that out of 214 natural science public school teachers studied in 2004-2005 under a teacher follow-up survey, 12,700 or 5.9 % left the profession. This number was even higher in private schools with 10.1 % (or 3,400) leaving the profession out of 33,400 teachers studied. In the study conducted by McCreight (2000), she stated that about 150,000 new teachers are hired in the United States every year to replace those who have left the profession. According to NCES (2007b), some of the reasons attributed to teachers leaving the teaching profession included: dissatisfaction with administrators support and dissatisfaction with work place conditions. According to Mangrubang (2005), the turnover rate of science and mathematics teachers is about 40%, while it is 29% for all teachers.

Shen, Gerard, and Bowyer (2009) conducted a study on the roles of policy makers and principals in increasing science teacher quality. The study investigated the federal and state policy makers and school principals as collaborators working together to improve science instruction. The data sources for this study included interviews, focused discussions, and policy documents. Study findings indicated that both policy makers and principals are supportive of giving incentives for teachers entering the science teaching profession. They also favor providing teacher training to new teachers in addition to using data to evaluate improved instruction. As stipulated in the National Science Board [NSB], 2004) 2020 Vision for National Science Foundation, “history suggests that a nation that relinquishes the torch of science puts is future prosperity at risk and jeopardizes its place in the history of civilization” (p. 1). United States’ students’ performance in science is below expectation when compared with some other developed countries (NSB, 2004; Schroeder, Scott, Tolson, Huang, & Lee, 2007). According to research, high quality teachers improve the science achievement of their students (Johnson, Kahle, & Fargo, 2007). The demand for highly qualified science teachers is higher than the supply. High attrition rates of science teachers leads to an increase in inexperienced science teachers in our schools, who are usually less effective than experienced science teachers (NSB, 2004).

In another study, Cohen-Vogel (2005) stated that there has been a scarcity of highly qualified science teachers for the past five decades. This has been a concern for the federal, state, and local policy makers’ (Marvel, Lyter, Peltola, Strizek, & Morton, 2006). Federal and state policy makers in the study came up with ideas as to ways to either reduce or completely drop a teacher certification requirement as a policy strategy for recruiting science teachers from the corporate sector. Some suggested offering test preparation courses that would enable professionals in the industries with science backgrounds to pass a state science credentialing test. One approach suggested attracting and recruiting industry professionals with solid mathematics and science backgrounds who could otherwise work in other sectors like the information technology and the insurance companies, to mention but a few. The policy recommended that the districts provide test prep courses that would enable these scientists to pass the state credentialing courses to become certified teachers. It was also recommended that when recruits became employed as teachers, provisions should be made to have these professionals go through continuous and coherent professional development for a sustainable career transition.

Federal and state policy makers and principals in this study suggested the integration of technology in science curriculum. This, they indicated, would be an attraction to the industry professionals from the corporate world transitioning into teaching. One of the barriers associated with technology enhanced science teaching and learning is financial constraints. Technology equipment is expensive and funding is scarce. Moreover some teachers advocate utilizing the fund that would have been spent on technology to increase teacher pay to bridge the gap between underpaid teachers' salary with that of other professionals.

Higher science teacher turn over and limited subject matter knowledge are issues of concern in science education (Marx & Harris, 2006). In a study by Marx and Harris (2006), federal and state policy makers and school principals agreed that science teachers need continuous professional support to improve science teaching and student achievement. This statement is consistent with Guskey (2000) who also stated that professional development should be an ongoing process and that educators should constantly have a continuous professional development. Guskey recommended that professional development should be followed with evaluation to determine its effectiveness, to enable participants reflect on their practices and make necessary changes and continually explore new alternatives and opportunities for improvement.

Student Science Academic Achievement

The goals of science education include (a) the production of enlightened students who would be able to make informed decisions on issues related to their lives, the society, and the world; (b) the training of individuals who would be able to make discoveries in science; and (c) the production of individuals who will be able to utilize science discoveries to benefit human. Advances in science are related to economic growth and national security. In terms of economic growth, a science literate nation has a better competitive edge compared with a nation that is not. This is because a science literate nation has more knowledge base to draw from in its quest to solve human problems. The technological breakthroughs arising from this knowledge are sold to the rest of the world, hence boosting the economy of the science literate nation. Science knowledge is also necessary for the production of sophisticated weaponry needed in times of war for a nation's defense and attacks.

U.S. science performance versus other industrialized nations. In 2006, the Paris based Organization of Economic Cooperation and Development (OECD) Programme for International Student Assessment (PISA) report stated that for 15 year-old students, the United States ranked 21st with 11 points below average. The United States ranked behind the following countries: Finland (the highest performing country), Canada, Japan, New Zealand, Australia, Netherlands, South Korea, Germany, United Kingdom, Czech Republic, Switzerland, Australia, Belgium, Ireland, Hungary and

Sweden (Bybee, 2008). In Trends in International Mathematics and Science Study in 2007, United States grade 4 students ranked 9th in science as opposed to 6th in 2003. Grade 8 students ranked 11th compared with the 9th in 2003. For both grade levels, the data shows a decrease in the performance of the United States students (NCES, 2007a).

In the 2009 PISA result released in December 2010, the United States ranked 17th in the OECD countries that participated with an average scale score of 502 (Fleischman, Hopstock, Pelczar, & Shelley, 2010). Though this score is better than that of 2006, there is no significant difference between them. Some of the countries in the top 10 in 2009 included: South Korea, Finland, Canada, Japan, Australia, New Zealand and the Netherlands.

There has been a national call to focus on improving K-12 science, technology, engineering, and mathematics (STEM) education. The integration of engineering education from kindergarten through high school has been identified as a key to sustaining the U.S. economy and standard of living (Oware, 2008). In order to improve science performance in schools starting at the elementary school level, science teachers need to be trained in scientifically proven methods of science instruction. Inquiry-based instruction where students explore the natural world, make observations, form hypotheses, and test their hypotheses not only helps to improve their science concepts, it also contributes to the intellectual and scientific development of the students (Lawson, 2008).

California student science performance. California student science performance is necessary in creating citizens who are science literate and who will (a) live a successful and fulfilling life; (b) make informed decisions on issues relating to the preservation of the society and the world, like air pollution and climate changes and; (c) make discoveries in science and apply science discoveries in enhancing lives; and (d) avail themselves of the numerous employment opportunities in science careers.

National Assessment of Educational Progress (NAEP). In 2000 and 2005 assessments of the National Assessment of Educational Progress (NAEP), California did worse than the rest of the nation in various categories of the science assessment report for California (U.S. Department of Education, 2005). California fourth grade students' average scale score was worse than the rest of the nation. Also, California students scored lower than the rest of the nation in basic and above and also in proficient and above in 2000 and 2005 (See Table 1).

Table 1

Average Science Scale Scores and Achievement Levels of California and the Nation for Grade Four Public Schools in 2000 and 2005 Assessments of NAEP

	2000		2005	
Jurisdiction	Nation	California	Nation	California
Average Scale Score	148	129	149	137
Basic and Above (%)	64	45	66	50
Proficient and Above (%)	28	13	27	17

Table 2

Average Science Scale Scores and Achievement Levels of California and the Nation for Grade Eight Public Schools in 1996, 2000, and 2005 Assessments of NAEP

	1996		2000		2005	
Jurisdiction	Nation	California	Nation	California	Nation	California
Average Scale Score	148	138	149	132	147	136
Basic and Above (%)	60	47	57	38	57	44
Proficient and Above (%)	27	20	29	14	27	18

Also in 1996, 2000, and 2005 California eighth grade students scored worse than the nation in average scale score. Also compared with the rest of the nation, fewer California students performed at basic and above. The same is applicable in proficient and above (See Table 2).

California standards tests (CST*).* In the United States, responsibility for the education of its citizens lies primarily with the individual states; however, with increasing evidence that many students, particularly minority and poor students, were failing to meet grade level standards and graduation requirements, the federal government felt its role must be increased. With the influence of the ideas in "A Nation at Risk" subsiding with time, there came the standard-based movement driven by the No Child Left Behind (NCLB) legislation of 2002. The NCLB was signed into law by President George W. Bush on January 8, 2002. The legislation put forth a system of accountability measures that promised to reward successful schools and sanction failing schools by the infusion or withdrawal of federal money. Each state had to devise a system of annual assessment where the outcomes were published in school accountability reports called the School Accountability Report Card. In California, two measures would be used to determine the success or failure of a school, Academic Performance Index (API) and Adequate Yearly Progress (AYP). The API is a measure of academic performance and progress of different schools in California. It is one of the main components of the Public Schools Accountability Act passed by the California Legislature in 1999. API is a number which goes from 200 to 1000 with 1000 being the highest. A school's API score shows its performance and this is calculated annually by the California Department of Education. For elementary schools, API is primarily based on the California Standards test (CST).

Science testing for grade 5 students started in 2004. Grade 5 is the only grade level that takes California standards test at the elementary level.

There are five performance levels for the CST. In decreasing order of performance these performance levels are advanced, proficient, basic, below basic, and far below basic. Out of these levels, only the scores of students who performed at the advanced and proficient levels are used for calculating the API for a school or school district.

Comparing CST performance from 2006 through 2010 (See Table 3), it can be seen from the data that there was a minimal steady increase in grade 5 life science performances as indicated by the mean scores from 2006 to 2010 (California Department of Education, 2010). There was also an increase in the number of students who scored at advance and proficient and a decrease in the number of students who scored at basic, below basic and far below basic from 2006 to 2010.

Table 3

Grade Five CST Performance Levels for 2006-2010 (Life Science)

	2006	2007	2008	2009	2010
Mean score	328.5	334.2	345.1	354	362.2
% Advance	6	9	13	18	24
% Proficient	26	28	33	31	31
% Basic	37	37	31	30	24
% Below Basic	21	15	13	12	12
% Far Below Basic	10	11	9	9	8

One of the purposes of the CST is to ensure that all students master the standards and that no student is left behind or allowed to perform poorly in core subject areas. The second intent is to bridge the achievement gap between different ethnic groups. In 2010 CST data, Asian, White, and Filipino students performed much better than the American Indian, Hispanic, and African American counterparts in CST as indicated by their mean scores (See Table 4). The same trend was repeated in terms of students who scored at proficient and above level. In terms of basic and below basic performance level, the order was reversed with most African Americans and the Hispanics tied in the highest, while there were less Asians and White students who scored at basic and below (California Department of Education, 2010).

Table 4

Grade Five CST Mean Scores for Various Ethnic Groups in Life Science in 2010

Ethnicity	Asian	White	Filipino	Amer. Indian	Hispanic	Black
Mean score	405.5	393.4	384.3	348.9	339.9	337.2
% Advance	48	40	34	17	13	13
% Proficient	29	35	38	33	30	29
% Proficient/Above	77	75	72	50	43	42
% Basic	14	16	19	26	30	28
% Below Basic	5	5	6	13	16	16
% Far Below Basic	4	3	3	11	11	13
% Basic and Below	24	24	28	50	57	57

Reports for economically disadvantaged students in 2010 CST indicated that the Asian, White, and Filipino students maintained higher scores compared with American

Indian, Hispanic, and Black (See Table 5). This shows a marked difference in achievement between the different ethnic groups with the African Americans showing the worst performance while Asians have the best performance.

Table 5

Grade Five CST Scores for Economically Disadvantaged Students for Different Ethnicities in 2010

Ethnicity	Asian	White	Filipino	American Indian	Hispanic	Black
Mean score	369.4	361.2	366.5	336.1	333.7	327.5
% Advance	27	22	24	11	10	9
% Proficient	34	36	37	31	28	26
% Basic	23	24	25	29	32	30
% Below Basic	9	10	9	16	18	19
%Far Below Basic	7	7	5	13	12	16

Report for grade 5 students who took the science portion of the CST in 2010 shows that 58% (27% plus 31%) of male students scored at proficient and above while 54% (22% plus 32%) of female students scored at proficient and above (See Table 6). The w difference is not statically significant. Also, 42% (22% plus 11% plus 9%) of males scored at Basic level or below while 45% (26% plus 12% plus 7%) of females scored at Basic level or below. Also there was no statistically significant difference in the performance of male and female students.

Table 6

Grade Five California Students CST Scores for Males and Females Who Scored at Different Performance Levels in 2010

	Males	Females	Difference (Males-Females)
% Advance	27	22	5
% Proficient	31	32	-1
% Basic	22	26	-4
% Below Basic	11	12	-1
%Far Below Basic	9	7	2
Total Number of Students Tested	219313	215814	3499

California science framework and fifth grade content standards. *Science for All Americans* (AAAS, 1990) of Project 2061 was a response to the advocates of science for all instead of for a few who were excelling in science. A reform document, *Science for all Americans* addressed what is required of all citizens to embrace science and technology education by recommending what ways of thinking that is essential to attain this goal. It went further to state that science education should prepare students to acquire the knowledge and critical thinking skills that they need to analyze and make informed decisions about living a fulfilling life today and beyond. Science education should also prepare students to work collaboratively with others in building and protecting the society. This groundbreaking document stated that America's future, from its ability to thrive in a just society, maintain a healthy economic vitality and maintain the safety of its citizens, depends on science. Also, global issues such as climate changes, over population, acid rain, the depletion of the ozone layer, to mention but a few, can be controlled by science or by taking necessary precautions as a result of science literacy. To address all these problems, we have to embark on the life-enhancing potential of science and technology, which we cannot realize unless we come to understand science, mathematics and technology and to acquire scientific habits of mind. *Benchmarks for Science Literacy* (AAAS, 1993) is a follow up document to Science for All Americans. It proposed that students should progress in their science education by stating what they should know and what they should be able to do at various grade levels up to grade 12.

Based on the recommendations of the *Benchmarks for Science Literacy*, followed by the publication of the National Science Education Standards (NRC, 1996), different states, including California, have benefited by utilizing the publication as a valuable resource in the creation of their state science standards.

In California, fifth grade students are required to cover grade 4 and grade 5 science standards for CST. Both grade level standards include physical science, life science, earth science, and investigation and experimentation. In grade 5, the main topic covered in physical science was electricity and magnetism. In grade 5, the main topic covered was elements and their combinations. In grade 4, life science, the overarching topic is all organisms need energy and matter to live and grow, while grade 5 covers plants and animals have structures for respiration, digestion, waste disposal, and transport of materials. In grade 4, earth science, two main topics are required to be covered: the properties of rocks and minerals reflect the processes that formed them and waves, wind, water, and ice shape and reshape earth's land surface. In grade 5, three main topics are required to be covered in earth science: water on earth moves between the oceans and land through the processes of evaporation and condensation, energy from the sun heats earth unevenly, causing air movements that result in changing weather patterns, and the solar system consists of planets and other bodies that orbit the sun in predictable paths.

Summary

In the United States, science inquiry instruction and the traditional text book method have been two contrasting approaches of science instruction that have been debated upon over the past 60 years. During most of this 60-year period, the traditional method of science instruction has dominated, except when there was an event that calls for deep science knowledge and achievement. For instance, after the launching of Sputnik in 1957 by Russia, the nation resorted to *inquiry* as an instructional method that would deepen the understanding of science concepts needed to give the nation a competitive edge in space exploration. After the release of “A Nation at Risk” in 1983, and as a result of the poor performance of the nation in international assessment, the nation again resorted to science inquiry instruction as a way of improving science achievement. In 1999, when the John Glenn Commission was created to report on the state of education in the nation as a result of the poor performance of U.S. students in international assessments, the committee recommended Inquiry as an instructional method that would help to deepen the understanding of science concepts.

The nation sees the benefit of inquiry strategy as an effective method of instruction. However, the nation needs to make concerted efforts in restructuring science curricula and support the use of inquiry in science instruction. Efforts towards this end are gradually gathering momentum with the release of reform documents like the National Science Education Standards (NRC, 1996) and the Benchmark for Science Literacy (AAAS, 1990, 1993). Available literature also reveals the lack of follow-up in professional development efforts on the use of inquiry instruction. Some inquiry professional developments are offered in piece meal manner, during summer, during the weekends, after school but there is often lack of follow up in the classrooms for continuous support to the teachers.

United States students' performances in local and international assessments have been abysmal. The reasons for this poor performance included the lack of highly qualified science teachers, ineffective instructional method, and a curriculum that is a mile wide and an inch deep. The literature reveals the achievement gaps which exist between students from different ethnic groups and socioeconomic statuses. With respect to closing the achievement gap advocated by Fullan (2006) and other education experts, *inquiry* has been found to possess the potential for meeting the academic needs of various students. It has been found to be effective with deaf students (Mangrubang, 2004), special education students (Palincsar et al., 2001), and English learners (Cuevas et al., 2005).

Finally, in the traditional teaching method, instruction is teacher-centered where the teacher does most of the talking and the demonstrations. Consequently, students find the traditional classroom boring, leading to apathy, poor understanding of science concept and poor science achievement (Lord & Orkwiszewski, 2006). Conversely, an inquiry classroom is student-centered where students do most of the talking, carry out experiments, draw conclusions, explain and justify their answers in addressing science questions (NRC, 1996). Students participate in their learning, develop critical thinking skills, and understanding of science concepts deepens (Newman et al., 2004).

Chapter 3: Methodology

The purpose of this study was to describe the perceptions of elementary teachers from an urban school district in Southern California regarding their inquiry-based science instructional practices, assessment methods, and professional development. To carry out this study, the following three factors were investigated: teacher practices, assessment methods, and the effective aspects of the professional development training they received. These three factors were examined among the volunteer respondents who participated in the CaMSP summer program through an online survey consisting of 20 Likert scale type items as well as a six-item structured interview protocol.

Research Design and Rationale

Mixed methods study was used. Mixed methods study is composed of both quantitative and qualitative research designs. Mixed methods studies are used when quantitative and qualitative components may provide a richer understanding of the phenomenon being studied. Also, it could be used in such a way that one method follows the other to better highlight, explain, or build on the results from the other approach (Creswell, 2009).

In this study, qualitative research alone through face to face interview was not used in order to avoid bias in response because of the relationships between the participants and the researcher. The researcher was the project director of the CaMSP project and had a good rapport with the participants after working together for 2 years. Quantitative method alone was not chosen due to the small sample size involved in this study, which might result in limited inferences of any statistical results, including those based on discrete statistics or t-tests.

Therefore both qualitative analyses through structured interviews and quantitative analyses using an online survey were integrated for an enrichment of the study through triangulation. To further increase validity, the respondents were made aware that their individual responses were not matched against their names. Findings from both the quantitative and qualitative data analyses were studied and compared, and similarities between the data were used for triangulation.

Setting

This study was conducted in an urban school district in Southern California. This district, which is about five miles radius, is located about 15 miles south of downtown Los Angeles in the county of Los Angeles, with an estimated population of 70,000 people. In 2007, the district enrolled approximately 18,211 K-12 students in 12 elementary, three middle, and two high schools, as well as one continuation school. In 2007, the majority of the students were Hispanic (91%) and African American (8%), and approximately, 44% were English-language learners. Almost 85% were economically disadvantaged, as measured by eligibility criteria for free or reduced-price meals. In 2007, the district was in Program Improvement Year 5 (PI 5). In California, some schools and districts receive Federal Title 1 funds to help them embark on programs to meet the educational needs of low-performing students in high poverty stricken schools in order to close the achievement gap. The performances of these schools and districts are measured by Adequate Yearly Progress (AYP). Schools or districts in PI 3 are those that have not made the AYP for at least 4 years. Moreover, in this school district being studied, all the six secondary schools were in program improvement. Prior to 2007, the secondary schools in this district scored from 536 to 614 API (Academic Performance Indicator) on

California Standards test (well below the 800 target goal set for all schools in the state). The district was committed to improving students' academic achievement and had many interventions programs for students in place. However, there were no system structures for sustaining these change processes.

Sampling Method, Sample, Participants

Purposive sampling was used for the selection of participants in this study. Purposive sampling is used in qualitative study in order to recruit the type of participants knowledgeable in the phenomenon being studied and who would provide the types of information required for a particular study (Patten, 2005). Hence, only the teachers who participated in the district's inquiry-based science training project, CaMSP or IBSRT program, would be able to provide the required data for this study. A total of 22 fourth through sixth grade teachers participated in this study.

Human Subject Considerations

The principal investigator received Pepperdine IRB approval before data collection (See Appendix A). Prior to the approval, the principal investigator successfully completed investigator training and received a certificate of completion before embarking on this study (See Appendix B). In order to ensure that the proper protocols were followed for protecting human subjects, the researcher was required to submit an application to the Institutional Review Board of Pepperdine University with the following documents: IRB certification (See Appendix B), permission to use survey instrument (See Appendix C), Informed Consent (See Appendix D), Teacher survey (See Appendix E), Teacher interview Protocol (See Appendix F), Superintendent or designee permission to conduct study (See Appendix G), and the faculty supervisor review form (See Appendix H).

With the approved informed consent, the researcher visited the teachers who participated in the district's CaMSP project and solicited their participation in the current study. Teachers who chose to participate signed informed consent forms and became participants. There were 33 teachers who completed the district's IBSRT program. Three of them retired at the end of the 2009-2010 school year. The remaining 30 constituted the sample from which the participants were recruited. All 30 teachers were invited to participate in this study making it a purposive sampling. Twenty-eight of them signed the informed consent, but 22 of them completed the online survey.

The CaMSP (IBSRT) Project

In the 2008-2009 and 2009-2010 school years, this urban school district in Los Angeles, California, participated in the California Mathematics and Science Partnership (CaMSP) project where the researcher in the current study was an employee and worked as the project director from 2008-2010. The CaMSP project was an inquiry-based professional development project funded by the National Science Foundation (NSF) under the auspices of the California Department of Education.

Through the CaMSP project, the district received $450,000 in the first year of the project from the California Department of Education. The California Department of Education paid each participating district $10,000 for each teacher participant per annum. The project started with 45 teachers in the first year. This number was reduced to 33 in the second year due to teacher attrition and the project was awarded $330,000. With this fund allocation, the project was able to pay the participants $800.00 per semester or

$1600.00 per school year. Also through this fund, the project was able to purchase Full Option Science System (FOSS) kits for the experimentation and hands on activities needed for the inquiry-based learning.

The 33 participants were distributed as follows; 10 were grade 4 teachers, 13 were grade 5 teachers, and the remaining 10 were grade 6 teachers. At the end of the 2010 school year, three of the participants who completed the training program retired reducing the number further to 30. Some of the teachers who left the project indicated involvement in multiple activity and lack of time to commit to the CaMSP project as their reason for withdrawal. Others were victims of reduction in force.

As stipulated in the request for application (RFA) for securing the CaMSP grant, the district partnered with an institution of higher education in California, which provided the scientists and professors who instructed the participants on science content knowledge and science inquiry process. The professional development model for this project was the five essential features of inquiry as contained and explained in the National Science Education Standards (NRC, 1996).

The CaMSP (IBSRT) grant was written by the district for elementary school teachers in grades 4 through 6 in an effort to improve the science achievement of elementary school students. There are 12 elementary schools in this urban school district and all grades four through six teachers in these schools were invited to participate. Participation was voluntary and participants were required to sign the informed consent at the beginning of (2008-2009). Teachers who missed this deadline were not allowed to participate. Although all the grades four through six teachers in the district did not participate, each school at least had a participant in the program. A total of 45 teachers signed up initially to participate in the program.

This Dissertation Study

For this study, 28 of the 30 teachers who completed the district's CaMSP training program signed informed consent forms and were given a copy of the signed consent form for their record. Their copy of the informed consent form contained the link to the online survey, their respondent identification number and directions regarding how to start the survey. A total of 22 teachers who completed the online survey were the participants in this study.

The informed consent form included the risks and rewards of being a participant. It also addressed the anonymity and confidentiality of participants. It expressed the strictly voluntarily nature of participating and the right of participants to withdraw from the study at any time. Also it expressed the non-mandatory requirement to answer all the teacher survey questions and the interview questions. The participants were informed that there would be a face to face interview to be conducted by the principal investigator and that it would be audiotaped with their permission. The informed consent contains the investigator's name and the contact information of where participants can direct any question or comment about their rights as research participants.

The risks in this study were minimal. However, participants could have sustained the following risks and discomforts: There was a discomfort in this study as a result of participants giving out personal information that has the potential of leaking to the public. To arrest this situation, the participants' information was protected by giving each one a unique code, which could be in the form of an identification number or a pseudo name to maintain the confidentiality of the participants. Also data collected were securely locked in a cabinet of which only the researcher had access. All the data collected will be kept for 5 years, after which it would be destroyed as indicated in the Publication Manual of the American Psychological Association, 6th edition (2010). Also participants may suffer from minor stress associated with completing the survey and answering the interview questions.

The potential benefits of this study to the participant would be that they could benefit from its results in terms of improving instructional practices that will eventually translate to improved students science understanding and achievement. The participants in this study will have an opportunity to find out the factors that either promote or inhibit the teaching and learning of science that they could incorporate in their professional repertoire. Also, the researcher will share the results of the study with the participating schools and school district highlighting factors that could enhance or impede the teaching and learning of science. The results will also be shared with the partner institution of higher education in the CaMSP project and this could help them to make informed decision about the necessary changes needed in their science teaching methods classes that would be more effective.

District Demographics

In 2007, the district enrolled approximately 18,211 K-12 students in 12 elementary, three middle, two high schools, and one continuation school. This comprises Hispanic (91%), African American (8%) and the rest were from other ethnicities (See Table 7). Approximately, 44% were English-language learners. Almost 85% were economically disadvantaged, as measured by eligibility criteria for free or reduced-price meals.

Table 7

District Demographic Data in 2007

Ethnicity	Enrollment	District %	County %
American Indian	7	0	0.3
Asian	12	0.1	7.7
Pacific Islander	42	0.2	7.7
Filipino	27	0.2	2.3
Hispanic	16,124	91.5	62.4
African American	1298	7.4	9.6
White	40	0.2	15.4
Multiple/NR	69	0.4	1.8
Total	17,619	100	100

Note. NR means no response.

It can be seen from the 2007 demographic data of this urban school district that it is composed of predominantly Hispanic students followed by African American students. These two subgroups represent the underserved part of the student population in the United States associated with a poor performance in science achievement. This study describes the perceptions of elementary teachers from an urban school district in Southern California regarding their inquiry-based science instructional practices, assessment methods, and professional development.

Instrumentation

Two instruments where used for this study. The teacher survey instrument was used for the quantitative data collection (See Appendix E) and an interview protocol was used for the qualitative data collection (See Appendix F). The teacher survey questions were originally designed by Coln (2008) and modified for this study (See Appendix I). The survey was pilot tested and vetted by expert professors, teachers, and others knowledgeable about inquiry-based instruction and or survey design. Reliability based on Cronbach's alpha was calculated as .936. Concurrent validity was also established. In the pilot study the Pearson correlation coefficient of .884 was found, suggesting a positive correlation between self-report and the instrument used to determine the amount of inquiry exhibited by the participants.

For the current study, the interview protocol was designed by the researcher with the supervision of a university professor knowledgeable in science inquiry and who participated in the district's CaMSP program as a professor and a professional developer. There were six open-ended questions aimed at delineating participants' perspectives on the three research questions about teacher practices, assessment methods and effective aspects of the professional development training. The first two of the interview questions focus on teacher practice (Research Question 1), the next two focus on teacher assessment methods (Research Question 2), and the final two (research question 3),focus on teachers' perceptions of the professional developments that they received (See Table 8).

Table 8

Research Questions and Factors Being Studied

Factors	Research Questions	Sub Questions
Teacher Practices: RQ-1	How do inquiry-trained elementary teachers in one Southern California district address the five essential features of science inquiry?	1. How do you apply the five essential features of science inquiry? 2. How do you regularly teach science topics to your students (your instructional practice)
Assessment Methods: RQ-2	How do inquiry-trained elementary teachers assess student performance related to each of the five essential features of inquiry?	3. How do you assess your students' science performance? 4. How do you assess the five essential features of science inquiry?
PD/Training: RQ-3	What types of training experiences are essential to fully prepare teachers to learn and apply inquiry in their classrooms?	5. What is your perception of the CaMSP Professional development? What do you perceive to be its strengths and weaknesses? 6. What recommendations do you have in terms of the ideal training program for preparing elementary teachers to successfully implement inquiry in their classrooms? How and why will these recommendations(s) be useful?

Data Collection and Procedures

The data for this study were collected from grades 4, 5 and 6 elementary teachers in an urban school district in Southern California who participated in the IBSRT project and who elected to participate in this dissertation study. Two data sets were collected for this study; the online survey data and the structured face to face interview data.

After the approval of the IRB application to conduct study, the online survey created by the principal investigator was launched in Zoomerang Pro, a web-based online survey tool. The researcher thereafter contacted and provided the participants with survey link and other pertinent information required to complete the survey.

Twenty-two participants participated in the online survey while a subset of this number (n=10) took part in structured face to face interviews with the principal investigator. The interviews were conducted at the convenient time chosen by the teachers in their classrooms. Most teachers chose to be interviewed after dismissal when their students were gone for the day while a few others, chose to be interviewed in the morning before school started.

The online survey data were analyzed using the NCSS statistical software. The audio-taped interview was transcribed into Microsoft Word, then organized and sorted. The emerging themes were identified and explained in detail for the understanding of the readers.

Analytical Techniques

The survey data were analyzed using the NCSS statistical software program. The researcher tested nine hypotheses (See Table 9) to describe teachers' practices and assessment methods after receiving inquiry-based science instruction and also the effective aspects of inquiry-based science professional development from the teachers' perspectives. The hypotheses included: Hypothesis 1: Inquiry-trained teachers engage learners in scientifically oriented questions. Hypothesis 2: Inquiry-trained teachers engage learners or students to give priority to evidence in responding to questions. Hypothesis 3: Learner formulates explanations from evidence. Hypothesis 4: Inquiry-trained teachers use investigations, research reports, projects to assess students' science performance. Hypothesis 5: Inquiry-trained teachers use constructed response essays to assess students' science performance. Hypothesis 6: Inquiry-trained teachers use portfolios, journals, lab notebooks to assess students' science performance. Hypothesis 7:

Expert modeling is an effective training experience essential to fully prepare elementary teachers to learn and apply inquiry in their classrooms. Hypothesis 8: Peer sharing is an effective training experience required to prepare elementary teachers to learn and apply inquiry in their classrooms. Hypothesis 9: Focus group discussion is an effective training experience required to prepare elementary teachers to learn and learn and practice inquiry in their classrooms.

Table 9

Research Questions, Hypotheses and Survey Items

Factors	Research Questions	Hypotheses	Survey Items
Teacher Practices	RQ, #1: How do inquiry-trained elementary teachers in one Southern California district address the five essential features of science inquiry?	Hypothesis #1: Inquiry-trained teachers engage learners in scientifically oriented questions.	1b, 1j, 2b, 4b, 4c, 4d, 4e
		Hypothesis #2: Inquiry-trained teachers engage learners to give priority to evidence in responding to questions.	2e,5a,5b,5c,5d,5e
		Hypothesis #3: Learner formulates explanations from evidence	3f,3h, 6a, 6b, 6c, 6d, 6e
Assessment Methods	RQ, #2: How do inquiry-trained elementary teachers assess student performance related to each of the five essential features of inquiry?	Hypothesis #4: Inquiry-trained teachers use investigations, research reports projects to access students' science performance.	1d, 1e, 1f, 1g, 1h, 1i, 1j, 2f, 3d, 3f, 3g, 9c
		Hypothesis #5: Inquiry-trained teachers use constructed response essays to assess students' science performance.	9b
		Hypothesis #6: Inquiry-trained teachers use portfolios, journals, lab notebooks to assess students' science performance	9d

(continued)

Factors	Research Questions	Hypotheses	Survey Items
PD/Training	RQ, #3: What types of training experiences are essential to fully prepare elementary teachers to learn and apply inquiry in their classrooms?	Hypothesis #7: Expert modeling is an effective training experience essential to fully prepare elementary teachers to learn and (Continued) apply inquiry in their classrooms.	11a
		Hypothesis #8: Peer sharing is an effective training experience required to prepare elementary teachers to learn and apply inquiry in their classrooms.	11b
		Hypothesis #9: Focus group discussion is an effective training experience required to prepare elementary teachers to learn and apply inquiry in their classrooms.	11d

The small sample size of the quantitative component is a limitation in this study. Studies have shown that larger samples are prone to yielding statistically significant results as opposed to small sample size (Patten, 2005). As a result of the small sample size, descriptive statistics were used to highlight sample characteristics, and no additional statistical tests were used.

The face to face audio-taped structured interviews were transcribed, organized, read, coded, and emerging themes identified, interpreted and explained in detail. Multiple coders were used. One was the researcher and the other was a statistician, an external coder, who is knowledgeable in qualitative studies and coding. The inter-coder agreement was then determined and explained.

The findings from the quantitative and qualitative data were then merged and studied for convergence or triangulation or for divergence or disconfirming. As the data were collected simultaneously in this dissertation study, concurrent triangulation strategy was used for data analysis. In concurrent triangulation strategy, the quantitative and qualitative data are collected simultaneously and comparison made to identify similarities and differences between the two findings (Creswell, 2009).

Chapter 4: Results

The purpose of this mixed methods study was to describe the perceptions of elementary teachers from an urban school district in southern California regarding their inquiry-based science instructional practices, assessment methods, and professional development. The quantitative data were collected through online survey (N = 22) (Appendix E), while the qualitative data were collected from the subset of these teachers (n = 10) through structured face to face interviews (Appendix F).

After separate analyses of the quantitative and qualitative data, they were merged using concurrent triangulation strategy where the two data sets were compared for similarities and differences. In concurrent triangulation strategy, the quantitative and qualitative data are collected simultaneously and comparison made to identify similarities and differences between the two findings (Creswell, 2009).

Quantitative Data Analysis

Quantitative data were gathered using online survey, hosted in Zoomerang Pro from the 22 teachers that participated in the study. The demographics of these teachers are as shown (See Table 10).

Table 10

Demographics of Participants

	Frequency	Percent
Gender		
Male	10	45.5%
Female	10	45.5%
Declined	2	9.1%
Years of experience		
0-3	0	0.0%
4-6	5	22.7%
7-9	6	27.3%
10-12	5	22.7%
13-15	2	9.1%
16+	3	13.6%
Declined	1	4.5%
Teacher certifications		
Certified to teach science in current grade	19	86.4%
Highly Qualified teachers	19	86.4%
National Board certified	0	0.0%
Average class size		
1-15	1	4.5%
16-20	0	0.0%
21-25	1	4.5%
26-30	14	63.6%
30+	4	18.2%
Declined	2	9.1%
Where teachers received inquiry instruction in professional education courses		
Bachelor's course work	3	13.6%
Master's course work	7	31.8%
Doctoral course work	0	0.0%
Certification program for teachers' credentialing	2	
None	8	36.4%
Declined	2	9.1%
Yes-attended 2 or more	2	9.1%
Declined	1	4.5%
Attended professional development that covered inquiry before CaMSP		
No	15	68.2%
Yes- attended 1	4	18.2%
Yes-attended 2 or more	2	9.1%

(continued)

	Frequency	Percent
Declined	1	4.5%
Attended professional development that covered inquiry before CaMSP		
No	15	68.2%
Yes- attended 1	4	18.2%
Yes-attended 2 or more	2	9.1%
Declined	1	4.5%

Note. N = 22

Out of the 22 teachers who participated in the online survey, 10 were identified as males, 10 were identified as females, and two did not identify their gender (See Table 10). In the sample, five (23%) of the teachers had 4-6 years of teaching experience, six (27%) had 7-9 years of experience, five (23%) had 10-12 years of experience, two (9%) had 13-15 years of experience, and three (14%) had over 16 years of experience (See Table 10). One teacher declined to indicate his or her years of experience. While the intended grade range for the teachers was from fourth to sixth grade, one of the fifth grade teachers who moved to grade three after receiving inquiry-based training participated in this study. Nineteen teachers were qualified to teach science in their current grade and are highly qualified. However, none has National Board certification (See Table 10). The average class size in this district for grades four through six is between 26 and 30 students per class (See Table 10). Three teachers experienced inquiry in bachelor's degree, seven in master's degree and two in certification for teachers, while eight teachers did not (See Table 10). Before CaMSP, 6 of the 22 teachers attended inquiry-based professional development while 15 of the teachers did not (See Table 10).

Research question 1. How do inquiry-trained elementary teachers in one southern California district address the five essential features of science inquiry? Three hypotheses were proposed by the researcher to study this research question (See Table 9).

Hypothesis 1: Inquiry-trained elementary teachers engage learners in scientifically oriented questions. Seven questions (survey items 1b, 1j, 2b, 4b, 4c, 4d, and 4e) were used to analyze what teachers said about hypothesis 1. The responses, which included *never, seldom, sometimes, often,* and *always*, were re-categorized into two groups of *never/seldom* and *sometimes/often/always* due to small sample responses within the intermediate response categories. The frequencies of these two groups were calculated using NCSS. All (100%) of the teachers responded that they have students pose questions in class *sometimes, often,* or *always*. A total of 61.9% of the respondents required their students to write lab reports *sometimes, often,* or *always*. All (100%) of the teachers have students engage in questions provided by the teacher, materials, or other sources *sometimes, often* or *always*. Among respondents, 81.82% of the teachers use questions to probe students' understandings *sometimes, often*, or *always*; 90.48% of the teachers have students select among questions and pose new questions either *sometimes, often* or *always*; 86.36% of the teachers have students pose questions *sometimes, often* or *always*; and all (100%) of the teachers allow students to sharpen or clarify question provided by the teacher, materials or other sources *sometimes, often* or *always*.

Hypothesis 2: Inquiry-trained teachers engage learners to give priority to evidence in responding to questions. Six questions (survey items 2e, 5a, 5b, 5c, 5d and 5e) were used to examine this hypothesis. All (100%) of the teachers required their students to make inferences from their observations; 86.36% of the teachers indicated that their students give priority to evidence in responding to questions; and 81.82% of the teachers indicated that their students determine what constitutes evidence and collect it *sometimes, often*, or *always*. Students of 90.91% of the teachers were directed to collect certain data, while students of 81.82% of the teachers were given data and asked to analyze it, and students of 90.91% of the teachers were given data and told how to analyze it *sometimes*, *often*, or *always.*

Hypothesis 3: Learner formulates explanations from evidence. Seven questions (survey items 3f, 3h, 6a, 6b, 6c, 6d and 6e) (See Table 9) were examined. In the sample, 77.27% of the teachers engage their students in an investigation of a topic before formally presenting the concept; 77.27% of the teachers engage their students in an investigation that takes more than one class period; 81.82% of the teachers have learner formulate explanations from evidence; 90.91% of the teachers have their students formulate explanations after summarizing evidence; and students of 86.36% of the teachers are guided in the process of formulating explanations from evidence *sometimes, often* or *always*. Among the respondents, 81.82% of the teachers gave students possible ways to use evidence to formulate explanations, and students of 95.45% of the teachers were provided with evidence *sometimes, often* or *always.*

Research question 2. How do inquiry-trained elementary teachers assess student performance related to each of the five essential features of inquiry? This research question covers hypotheses 4 through 6.

Hypothesis 4: Inquiry-trained teachers use investigations, research reports projects to assess students' science performance. The specific survey questions for these analyses were 1d, 1e, 1f, 1g, 1i, 1j, 2f, 3d, 3f, 3g and 9c (See Table 9). A total of 81.82% of the teachers engage their students to make observations in class; 90.91% of the teachers require their students to take measurements in class; 81.82% of the teachers require their students to manipulate experimental materials providing a hands-on experience; and 63.64% of the teachers have their students design their own experiments or investigations *sometimes, often* or *always*. Among the teachers, 72.73% of the teachers engage their students in investigation or lab; 61.90% of the teachers require their students to write up a lab report; 77.27% of the teachers use experiments from the text or lab manual; 77.27% of the teachers have their students engage in an investigation on a topic before formally presenting the concepts in class; 76.19% of the teachers revise experiments from the text or a lab manual to make them more open-ended; and 81.82% of the teachers use investigations, research reports, and projects *sometimes, often* or *always.*

Hypothesis 5: Inquiry-trained teachers use constructed response essays to assess students' science performance. The specific survey question for testing this hypothesis was 9b (See Table 9), and 81.82% of the teachers use constructed response essays to assess students' science performance while 18.18% of the teachers do not.

Hypothesis 6: Inquiry-trained teachers use portfolios, journals, lab notebooks to assess students' science performance. The specific survey question for testing this hypothesis was 9d (See Table 9), and 77.27% of the teachers have student learners use portfolios, journals, or lab notebooks *sometimes, often* or *always* while 22.73% of the teachers do not.

Research question 3. What types of training experiences are essential to fully prepare elementary teachers to learn and apply science inquiry in their classrooms? This research question covers hypotheses 7 through 9.

Hypothesis 7: Expert modeling is an effective training experience essential to fully prepare elementary school teachers to learn and apply inquiry in their classrooms. The specific survey question for this hypothesis was 11a, and 95.24% of the teachers responded that expert modeling was an effective training experience essential to fully prepare elementary teachers to learn and apply inquiry in their classrooms.

Hypothesis 8: Peer sharing is an effective training experience required to prepare elementary teachers to learn and apply inquiry in their classrooms. The specific survey question for this hypothesis was 11b, and 95.24% of the teachers indicated that peer sharing was effective.

Hypothesis 9: Focus group discussion is an effective training experience required to prepare elementary teachers to learn and apply inquiry in their classrooms. The specific survey question for this hypothesis was 11d, and 90.48% of teachers indicated that focus group was effective.

Qualitative Data Analysis

Ten of the 22 teacher participants participated in the face to face interview. The 10 teachers consisted of five males and five females from five different schools in the district. Two teachers were African American, one was a Caucasian, and the remaining seven teachers were Hispanic. Their years of experience range from 6 to 20 years (See Table 11). Six of the teachers categorized as new teachers had 0-10 years of experience. The new teachers were two males and four females. The experienced teachers included four teachers with 11 or more years of experience, and 75% of the experienced teachers were male. The interview participants were also selected purposively but stratified on the basis of gender, experience and school site. This process has the potential to increase the validity of the study.

Table 11

Demographics of Teachers Interviewed

Teacher	Grade	School	Gender	Ethnicity	Years of Experience
Teacher	4,5,6	A	Female	African American	12
Teacher 02	4	B	Male	Hispanic	15
Teacher 03	6	B	Male	African American	13
Teacher 04	5	C	Female	Hispanic	7
Teacher 05	5	C	Male	Hispanic	9
Teacher 06	5,6	A	Female	Hispanic	7
Teacher 07	5	A	Female	Hispanic	6
Teacher 08	5	D	Female	Hispanic	8
Teacher 09	4	E	Male	Caucasian	20
Teacher 10	6	D	Male	Hispanic	6

Note. n = 10

From the interview data collected (See Appendix J), the emerging themes from the research questions were delineated.

Research question 1. How do inquiry-trained elementary teachers in one Southern California district address the five essential features of science inquiry?

The consistent themes with this research question were questioning and explanation.

Questioning. In total, 7 of the 10 respondents indicated the use of questioning in their process of using science inquiry in their classes. Teachers indicated that they ask questions of their students to get topics started, encourage them to ask questions, and motivate the students to inquire about why specific scientific experiences occur as they do. Teachers indicated that students use their questions to highlight problems or findings they have difficulty interpreting in their explorations, and it also provided the teachers with an opportunity to gauge the understanding of their students after going through the process of science inquiry through open ended/multiple choice/fill in the blank questions on class tests, writing out procedural approaches to what they have studied, or through general discussion of the science topic. At least one teacher indicated the use of science projects in the class to allow students to answer the questions related to a specific science topic the students had. Other teachers indicated that students were able to work together to define questions of interest to them that they could explore using scientific method procedures. Teachers also indicate asking questions of the students to determine what knowledge they already had with regard to a specific topic. Finally, at least one teacher highlighted that the process of asking questions was the same regardless of level of experience of the scientist and encouraged students to ask questions to indicate that this was specifically what the field of science is about. Teachers reported encouraging students to ask questions, and then thanking the students for asking because the teacher felt that the question not only encouraged discussion, but highlighted some of the student's previous knowledge as well.

***Explanation*.** Seven of the 10 teachers reported the process of explanation occurring in their classrooms, primarily through having the students explain the processes occurring in their scientific inquiries, whether it is based on experiments/hands on activities, their personal experiences, or their hypotheses of the ongoing scientific process they are studying. The discussion reportedly has led to the development of experimentation in the classroom, and the explanation of what has occurred. The experiment is often validated with information learned from their textbooks and previous knowledge. Some teachers reported not explaining a specific science topic to the students to initiate interest; rather, they allowed the students to explain and highlight what they already knew about that particular topic or what they had seen or heard via other sources about this topic. Teachers also reported discussion among students within the classes regarding the experiments they had completed, and the discussion/explanation process of what has occurred has been reported by the teachers as one approach that has been used to evaluate student learning on some specific science topics. Teachers also report having students explain what they literally carried out, saw, and understood from their experiences, which motivated additional activities to take place in the class thereafter.

Research question 1 and interview questions. How do inquiry-trained elementary teachers in one Southern California district address the five essential features of science inquiry in their classrooms?

The interview questions used to glean the perspectives of the teachers in question 1 of the qualitative study were:

1. How do you apply the five essential features of science inquiry in your classroom?

2. How do you regularly teach science topics to your students (your instructional process)?

Responses to research question 1 based on gender. How do inquiry-trained elementary teachers in one Southern California district address the five essential features of science inquiry in their classrooms?

In addressing research question one, all the female teachers interviewed talked about using questions to tap into students' prior knowledge and actively involving them in their learning. They talked about using lab, experimentation, and investigation to actively involve the students in their learning. As one of the teachers put it:

> A lot of the features come naturally when you do the hands-on lab. I remember the beginning when with the students when we did our first lab, I as the teacher will pose the questions to them, to get them to use the proper vocabulary, things like that and through the hands-on experience, they get to see the answer and get to respond to it and explain why it happened. And then, in the next day or the preceding lessons, we will be able to look in the textbook or the resources that we have, so they could find a connection and then as we did more and more labs, they will on their own pose the question and explain it and give the evidence that they saw through the labs in their hands-on experiences.

Three of the five male teachers also talked about having students actively involved. However all of them highlighted the use of questioning and explanation in the classroom. As one teacher put it:

> In my classroom, I try to, first off, I always keep the students engaged- try to pick something interesting they can look at or touch- the hands on approach- that's how I get them engaged. We later on try to explore the concepts. Sometimes I try to backload it with some information we saw in a book. For the explanation of that, we use a combination of what we learned in the book combined with the hands on activity we did in the classroom. To extend, I at least try to have them to create their own project of some sort that they can try at home, and maybe do a report, or a slideshow, or some kind of diorama with, and I evaluate that by using what they produce as far as the project goes or sometimes there is a written assessment.

Responses to research question 1 based on new and experienced teachers' perspectives. For this study, new teachers are the ones with 0-10 years of teaching experience while experienced teachers are teachers with 10 and above years of teaching experience. All new teachers talked about having students actively engaged in class during science instruction. They also talked about how to use questioning to tap into their prior knowledge and build on that knowledge. For the experienced teachers, though they all talked about taping into students' prior knowledge, 3 of the 4 teachers talked about having students actively involved.

Research question 2. How do inquiry-trained elementary teachers assess students' performance related to each of the five essential features of science inquiry?

A consistent theme with this research question was experimentation. Every teacher in the study reported the use of investigation or experimentation in their science classes. Some teachers reported the process of investigation in their courses highlighting the study of rocks and minerals; some examined litmus paper; another teacher used the process to indicate that air has mass. Many teachers used exploration as a method of experimentation to engage the students in a particular topic and to provide students with the information and ideas they needed to prepare to explain what processes they saw occurring in their science experiments. Teachers reported the process of science inquiry occurred rather commonly and naturally with the use of experimentation in the class through hands on labs. Teachers indicated providing handouts regarding the lab experiments they used or providing guidance for the students conducting their experiments, as well as requiring the students to write up lab reports of their experiments.

In terms of teacher experience with the program, the teachers indicated that a strength of the program was around the availability of FOSS kits for experiments, but teachers also preferred to have texts that provide more experiments for their classes, and one weakness of the program that was highlighted with regard to experimentation was lack of literature explaining some of the concepts around the experiment that could be integrated into their course right away. Teachers also preferred to have the materials regarding experiments long in advance of class starting and would prefer to experiment with the materials used in an experiment before the experiment should be carried out in class. Teachers reported a lack of funds to do science experiments as well.

Research question 2 and interview questions. How do inquiry-trained elementary teachers assess student performance related to each of the five essential features of science inquiry?

The following interview questions were used to glean participants' perspectives on research questions 2:

1. How do you assess your students' science performance?

2. How do you assess the five essential features of science inquiry?

***Responses to research question 2 based on gender*.** Four out of the five female teachers discussed using class participation to assess students' science performance. They use students' presentations, response to questions asked in class, performance in experiment, questions asked by students in class, and ability of students to recount lesson learned to someone else to assess students' science performance.

However, one of the teachers, teacher-07, and uses mainly multiple choice questions for assessment. The teacher talked about the insufficient time for inquiry instruction which has left her with no other option but to revert to paper and pencil assessments.

> It is through an assessment that has multiple choice questions or has open- ended questions. Sometimes they have to draw a picture to show me a model of something for example of an atom. They have to draw the picture of the atom and label it to see if they know all the parts of the atom and what the parts mean in regard to what the atom is.

All the male teachers talked using open-ended questions to assess students. Other methods of assessment proffered by these teachers include students input in class, students' performance during class activities, response to questions and ability to explain what was learned to someone else. As one male teacher put it:

> Sometimes I assess them with actual written exams, so that's one of the ways. I also asses them as y my observations- I observe them when they're doing experiments or doing labs in the classroom. I also observe their input in class- whatever they write down on experiments- I also look at the information they write down, what they came back with at the end of the lesson. Those are some of the things I look for.

Responses to research question 2 based on new and experienced teachers' perspectives. There were 6 new and 4 experienced teachers in the list of the teachers interviewed. New teachers emphasized the use of paper and pencil assessments while experienced teachers emphasized the use of observation during experiment and students' response to class discussion for assessment.

Research question 3. What types of training experiences are essential to fully prepare teachers to learn and apply inquiry in their classrooms?

The consistent themes with this research question were knowledgeable professors, lack of sufficient time for science instruction and involve more or all teachers.

Knowledgeable professors. This was highlighted as strength of the program by the teachers. At least three teachers indicated that the instructors were very knowledgeable about the process and helped the teachers experience and understand the process as students. Teachers highlighted the variety of aspects from which the information was shown and explained to them, which made the information more useful. Teachers also indicated that the knowledge to be gained from this program reminded the teachers that they were not always the experts, and at least one teacher reported needing to learn with the kids.

***Insufficient time for science instruction*.** This was highlighted as a weakness of the program. Seven of the teachers interviewed talked about insufficient instructional time in implementing science inquiry instructional strategies that is more time consuming in their classrooms. Some of them indicated how the school administrators exacerbated the situation by reducing science instructional time to increase mathematics and English language arts time that are tested in California Standards test at all grade levels. In California, only grade 5 students receive science assessment in California standards test.

***Involve more or all teachers*.** This was highlighted as one of the recommendations in terms of the ideal training program for preparing elementary teachers to successfully implement inquiry in their classrooms. At least three teachers interviewed gave this recommendation. One of them said

> The only weakness I can see was that the program was not allowed to proceed and incorporate newer participants as some participants received pink slips. It would have been most helpful to have more and more teachers in this district to be aware of the ability to teach real science using relatively common things.

Research question 3 and interview questions. What types of training experiences are essential to fully prepare elementary teachers to learn and apply inquiry in their classrooms?

The following interview questions were used to glean participants' perspectives on research questions 3:

1. What is your perception of the CaMSP professional development? What do you perceive to be its strengths and weaknesses?
2. What recommendations do you have in terms of the ideal training program for preparing elementary teachers to successfully implement inquiry in their classrooms? How and why will the recommendation(s) be useful?

Responses to research question 3 based on gender. Regarding the strengths of the professional development, some of the teachers talked about the availability of FOSS kits that has made hands-on activity possible, the content and pedagogical knowledge they gained. One talked about the exchange of ideas and lessons shared by peers.

> Well, I have to say that I did learn a lot. Science was definitely one of my weaknesses. And after going through CaMSP, I learned so much more on how to teach it because I myself, I know the science. But to teach it to the students is a whole different realm. So through CaMSPs, I was able to learn many hands on lab for physical science and for earth science as well. It is definitely a strength. I appreciated the ability to talk to other teachers in my grade level to see what they were doing to make things work. I like that we were able to exchange our ideas. I remember we were also able to bring in what we have done with the students so that our peers could see it, and they could tell us what they thought the kids got out of it and how we can make it better. We were also given the opportunity to share lessons that we have done that were not given to us through CaMSP so that also helped us a great.

Other themes that came up here were insufficient time for science instruction and involve all teachers. Insufficient time for science instruction was highlighted as a weakness of the program. Three of the female teachers talked about insufficient time for science instruction. In addition, they talked about how science instructional time has been reduced to increase the time for mathematics and English language arts (Griffith, 2008). Unlike science, students' performances in English language arts and mathematics contribute to a schools' Adequate Yearly Progress (AYP) as demanded by No Child Left Behind.

More modeling also came up as a theme under recommendation by female teachers. Female teachers talked about the need to see more modeling of science inquiry instruction and to possibly visit a classroom or classrooms where it is being implemented by experts teaching their students.

Three male teachers talked about knowledge gained from the knowledgeable professional development professors. As one teacher puts it:

> I really-I must say I really enjoyed the professional development. I especially liked that it was inquiry based. They allowed us to build upon what we already know, plus they gave us additional information as far as inquiry based lessons-how to get our own lessons that we currently have and make them better using inquiry and other methods that they also used, and they also gave us some really good ideas about lessons, and we did some actual lessons during the professional development which was actually helpful in terms of becoming a better science teacher.

Other perspectives of the male teachers include involve all or more teachers. One teacher said:

> My recommendation is to have the whole staff in this type of training. They are definitely going to benefit from it. And if every, the whole school is trained, then the students we will receive the following year, they have been exposed to the five essential standards, the five E's of the inquiry, so they are already familiar with it, and they are going to be stronger in science, and they are going to definitely succeed in science if we start from the bottom, and all the teachers are already experienced. But definitely they need to be trained in this- the whole staff, not just particular teachers. So definitely I recommend that the whole staff be trained so that the school can be successful and that the kids can be successful in science.

Responses to research question 3 based on New and Experienced teachers' perspectives. Three out of six new teachers talked about insufficient time for inquiry instruction and the reduction of their inquiry lessons as a result, while three out of the four experienced teachers talked about the benefit of the program and the need for the district to make it mandatory for all teachers for the ultimate benefit of all of teachers and students. As one experienced teacher stated:

> I think that as a teacher I know what good teaching skills and good programs look like. I've been through good ones and bad ones and this is a good one. I think teachers should have a voice, and I think that if this was mandatory we would see a big jump not only in the science scores but in the math and in the writing abilities of the students because it is hands on, it explains itself, and it makes it easy…it's easy to teach if you have the materials, and you've actually been trained, and it's easy for the students to learn, and after each step it almost checks itself. It makes the planning easy. So it's something that if all teachers had access to it, we could work together, and one teacher could plan an activity and somebody else- we could all just build a whole new science curriculum, using the books as well and the standards- we can build the thing quicker and in collaboration together and it would work a lot better than having one teacher from each school or each grade having to come back and teach the rest. Sometimes as fellow teachers it is hard to get the same respect as an outside person coming in would get. So I just think it should be mandatory for all teachers to go through at least once.

Themes from multiple coders. The qualitative data were analyzed by two coders. One was the researcher and the order was the statistician, an external coder. There were similarities and differences in the codes but both agreed to concentrate on using the codes that were similar (italicized) in code explanation (See Table 12). Based on the teacher responses regarding their implementation of inquiry features in the classroom, the data suggest that most commonly, the majority of teachers use questioning to apply the features of science inquiry. They also reported using experimentation with the students, encouraging the students to explain and provide clear conclusions about the science they learned, they encouraged the students to explore and engage in classroom activities that examined specific scientific topics, and they used hands on activities as well to engage the students. To teach science topics to their students, the teachers reported, frequently, relying or engaging student's previous knowledge to develop an understanding of a specific scientific topic. Teachers reported frequently using questions to ask the students what they know, but also encouraged students to ask questions regarding the topic. Teachers provided exploratory activities for the students to learn about a new topic. Teachers also indicated a use of textbooks whether for providing students with a reference manual or for introducing the topic to the students.

Table 12

Summary of Themes from Multiple Coders

Factors	Research question	Interview Questions	Themes from first coder-researcher	Themes from second coder-(Statistician)
Teacher Practice	How do inquiry-trained elementary teachers in one Southern California district address the five essential features of science inquiry?	1. How do you apply the five essential features of science inquiry? 2. How you regularly teach science topics to your students (your instructional practice)	1.*Questioning* 2.*Explanation*	*1.Questioning* *2.Explanation* 3.Experimentation 4.Hands-on activities 5.Previous knowledge 6.Questioning 7.Explorations

(continued)

Factors	Research question	Interview Questions	Themes from first coder-researcher	Themes from second coder-(Statistician)
Assessment methods	How do inquiry-trained teachers assess student performance related to each of the five essential features of inquiry?	3. How do you assess your students' science performance? 4. How do you assess the five essential features of science inquiry?	*1. Experiment* *2. lab*	1. Projects 2. Questioning *3. Exploration* *4. Experiment*
Training Effectiveness	What types of training experiences are essential to fully prepare teachers to learn and apply inquiry in their classrooms?	5.What is your perception of the CaMSP Professional development? What do you perceive to be its strengths and weaknesses? 6. What recommendations do you have in terms of the ideal training program for preparing elementary teachers to successfully implement inquiry in their classrooms? How and why will this recommendation (s) be useful?	Strength: 1.*Knowledgeable professors* 2.*Availability of kits* Weakness: 3.Insufficient time for science Recommendation 4. Involve more teachers in the program. Strength *1. Hands on material* *2. Knowledgeable professors* 3. Confidence Weaknesses: No common themes identified	

For assessment of student performance, teachers reported using measures of class participation, such as engagement in discussions or active participation in the classroom activities. This was specifically the case for the teacher who was leading the special education class. Teachers also reported using projects to allow students to demonstrate their knowledge of the subject, as well as through asking questions of the students and allowing them to verbally answer in class. With regard to questioning, teachers also reported having students talk to others who are unfamiliar with their science projects, such as family members, and using their ability to explain the topic to others as a gauge of their understanding. Written assessments were also used to assess student learning, through multiple-choice tests, open ended questions, writing projects, and through reading their scientific lab notebooks. In response to questions about how the teachers directly assess the five features of scientific inquiry, the majority of teachers reported talking and explaining as the primary mechanism through which they assessed the features. While explanation was commonly discussed in regard to talking, teachers also reported investigations through student explanations in writing.

Strengths reported regarding the program were focused on the facts that the program has several opportunities for hands on engagement of the teachers. While no other responses were reported among the majority, the teachers reported that the professors were knowledgeable and provided good information. Weaknesses highlighted were not consistent across teachers; however, the reasons provided included that the training was not mandatory for all teachers, which would provide consistency in teaching approaches across teachers within a school, and the lack of that there is not enough time in the science classroom to carry out such activities. This was supported by the notion that one teacher reported a lack of the program integration on the part of the administration within the schools. In terms of recommendations, teachers suggested having the training occur for their entire staff, as well as yearly provisions of the program.

Other findings of interest. Some teachers in this study were not teaching science before the district's inquiry-based science professional development CaMSP project. They indicated that they started teaching science after the CaMSP program, having increased their content and pedagogical knowledge and increased their science teaching confidence. Now these teachers are so delighted with the outcome from the training that they are now advocates for a district-wise inquiry training that would benefit all teachers and students.

Triangulation of quantitative and qualitative data. After the collection of the quantitative and qualitative data, they were analyzed and then triangulated. Triangulation shows the relationship between the data. Similarities in the data strengthen the validity of the study. Validity or trustworthiness is one of the strengths of a qualitative research. It is the extent to which the findings of a qualitative study accurately represent the perspectives of the researcher, the participants, or the readers of an account (Creswell & Miller, 2000). A number of factors strengthened the validity of this study. Triangulation of the quantitative and qualitative data added to the validity of this study, the detailed description of the findings including disconfirming perspectives of some participants and the fact that the entire study was reviewed by an external auditor all added to the validity of this study (See Appendix K).

Summary

In exploration of research question 1 about teacher practices after receiving inquiry instruction, quantitative data analyses suggested that most teachers supported the use of questioning and explanation in their classrooms. This was corroborated by qualitative data analysis where questioning and explanations emerged as themes for research question 1. The data from two different data sources corroborating each other strengthens the validity of the study.

In research question 2, which is about teachers' assessment methods after receiving inquiry training, quantitative data analysis revealed that teachers supported the use of experimentation for student science assessment. Experimentation also emerged as a theme in qualitative data analysis of the assessment method after receiving inquiry instruction. Obtaining the same results from two different data sources strengthen the validity of this study. Teachers talked about engaging students in experimentation, hands on activity and investigation and how they assess students through observation during experimentation.

For research question 3 regarding professional development, quantitative data supported the expert knowledge of the professional developers. This was corroborated by the qualitative data where knowledgeable professors appeared as a theme, in the qualitative data analysis. Though not tested as a hypothesis in the quantitative data analysis, teachers during the semi structured face to face interview discussed about insufficient time for science instruction and how the administrators have exacerbated the situation by decreasing science instructional time to increase English and Language Arts time that are tested in the CST.

About three of the teachers interviewed recommended involving all or more teachers in the district in future inquiry professional development. As they stated, more teachers and students will be able to avail themselves of the potential inherent in inquiry instruction.

Chapter 5: Conclusions and Recommendations

The purpose of this mixed methods study was to describe the perceptions of elementary teachers from an urban school district in Southern California regarding their inquiry-based science instructional practices, assessment methods, and professional development. The study examined teacher practices, assessment methods, and the effective aspects of the inquiry professional development they received for 2 years. The district partnered with an institution of higher learning for the inquiry-based professional development of these teachers called the California Mathematics and Science Partnership (CaMSP) project. The institution of higher learning provided the scientists, professional developers, or professors who instructed the teachers on the use of science inquiry in their classrooms.

During this 2 year period, from 2008-2009 school year to 2009-2010 school year, these teachers received intensive inquiry training in each summer preceding the school years. These were all-day trainings for 8 consecutive days of 7.5 hours per day giving a total of 60 hours per summer. In addition, the teachers received one all-day follow-up session per month for the rest of the school year. Teachers who participated in the CaMSP project were supplied with FOSS kits for their science inquiry instructions. These kits were composed of science lessons and equipment and directions on how to use the kits for experimentation and investigation. Also the teachers were taught how to use locally available materials for science instruction in the absence of FOSS kits.

Thirty teachers who completed the inquiry-based professional development of this district were invited to participate in this dissertation study. Twenty-two of them, which is a response rate of 73.3%, agreed to participate. As an employee of this district, the researcher was the project director of the district's inquiry professional development and was responsible for the overall management of the CaMSP project. The researcher was a member of the leadership team, composed of the professors, external evaluator, and the project director. The researcher organized all the professional development trainings and supported both the district teachers and the professors for the successful implementation of the project. Three research questions were created for this study. Research question one addressed teacher practices, research question two addressed the assessment methods, and research question three addressed the effective aspects of the professional development. Each research question has two sub questions.

For the quantitative study, three hypotheses were proposed and tested for each research question given a total of nine hypotheses. Data for testing the hypotheses were collected through an online survey (See Appendix E) about 18 months after the professional development ended. For the qualitative component of this mixed methods study, a subset (n = 10) of the 22 participants had a face to face interview with the principal investigator. Data were collected from the participants from their responses to six interview questions that were audio-taped. Two interview questions targeted each of the three factors (teacher practices, assessment methods, and professional development) being studied (See Appendix F).

The survey items were borrowed from a previous study instrument on inquiry-based instruction. Most of the items of the previous instrument were borrowed for this study, few were reworded and more items were added to test new hypotheses introduced in the current study. The study for which the old survey instrument was designed was the extent to which science educators in grades 3-8 in a mid-sized district in North Carolina reported practicing inquiry-based instruction in their classrooms and to identify factors related to the use of inquiry (Coln, 2008). The survey items were structured after the theoretical framework of the National Science and Education Standards (NRC, 1996).

Likewise, the interview questions were specifically designed to mirror the process skills of the National Science Education Standards (NRC, 1996). The face to face interviews were audiotaped with the consent of the participants. These were later transcribed, coded and analyzed by multiple coders, the principal investigator and a statistician, an external coder. The face to face interviews were conducted in the participants' classrooms at their convenient time. Most of the teachers chose to be interviewed in their classrooms after dismissal. However, a few others opted to be interviewed early in the morning before school started. The interviews were conducted in a cordial manner and in low anxiety atmosphere, attributable to the rapport the researcher and the participants have built over the years of working together.

Research Question 1: Conclusions

How do inquiry-trained elementary teachers in one Southern California district address the five essential features of science inquiry in their classrooms?

The quantitative analyses of this research question indicated that these teachers engaged learners in scientifically oriented questions, engaged learners to give priority to evidence in responding to questions, and they also allowed students to formulate explanations from evidence. These are all indicators of inquiry instruction as contained in the National Education Standards (NRC, 1996). The following items tested; 7 for hypothesis 1, 6 for hypothesis 2 and 7 for hypothesis 3, supported the use of inquiry instruction by these teachers. The skill of inquiry mostly used by these teachers are questioning, utilized by all the teachers, requiring students to make inferences from their observation, all the teachers, learner is directed to collect certain data, used by 90% of the teachers, learner is given certain data and told how to analyze the data, used by 90% of the teachers, and learner formulates explanations after summarizing evidence, 91%. The areas of less inquiry use include; require students to write up a lab, 61% of the teachers used this, have the students engage in an investigation on a topic before formally presenting the concepts in class, 77% of the teachers used this and engage students in an investigation that takes more than one class period, used by 77% of the teachers (Table 13).

On the qualitative data analysis, questioning emerged as a theme. All the teachers interviewed indicated the use of questioning in their classrooms during science instruction, which corroborated the data from the quantitative data analysis (Table 13). Another theme delineated in the qualitative data analysis was explanation which also supports the quantitative result. Teachers elicited explanations from students when they posed questions to them. During the question and answer sessions that ensued, teachers indicated that they were able to determine the students' misconceptions and clarified them. They indicated that they were able to determine the students' background knowledge on the topic being discussed and built on them. This corroborates literature on inquiry implementation (NRC, 1996; Makang, 2003; & Coln, 2008).

Table 13

Data triangulation for Research Question 1

Research question	Quantitative Results of survey questions that support inquiry	Qualitative Results of structured interview themes
RQ-1 Teacher Practice How do inquiry-trained elementary teachers in one Southern California district address the five essential features of science inquiry?	<u>Hypothesis 1</u> •Have students pose questions-100% •Require students to write up a lab report-61% •Use questions to probe students' understandings– 100% •Learner selects among questions, poses new questions 81.82% •Learner poses a question - 90.48% •Learner sharpens or clarifies question provided by teacher, materials, or other sources –86.36% •Learner engages in question provided by teacher, materials, or other source - 86.36%%	1.Questioning 2.Explanation
RQ-1 Teacher Practice How do inquiry-trained elementary teachers in one Southern California district address the five essential features of science inquiry?	<u>Hypothesis 2</u> •Require students to make inferences from their observations- 100% •Learner gives priority to evidence in responding to questions – 86.36% •Learner determines what constitutes evidence and collects it -81.82% •Learner is directed to collect certain data –90.91% •Learner is given data and asked to analyze -81.82% •Learner is given data and told how to analyze – 90.91%	1.Questioning 2.Explanation

(continued)

Research question	Quantitative Results of survey questions that support inquiry	Qualitative Results of structured interview themes
RQ-1 Teacher Practice How do inquiry-trained elementary teachers in one Southern California district address the five essential features of science inquiry?	<u>Hypothesis 3</u> • Have the students engage in an investigation on a topic before formally presenting the concepts in class -77.27% • Engage students in an investigation that takes more than one class period –Support 77.27% • Learner formulates explanations from evidence - 90.91% • Learner formulates explanation after summarizing evidence –90.91% • Learner is guided in the process of formulating explanations from evidence - 86.36% • Learner is given possible ways to use evidence to formulate explanation –86.36% Learner is provided with evidence - 95.45%	

Research Question 2: Conclusions

How do inquiry-trained elementary teachers assess students' performance related to each of the five essential features of science inquiry?

For the quantitative analysis of this research question, 12 survey items were tested for hypothesis 4, one for hypothesis 5 and one for hypothesis 6. The most practiced inquiry skills as indicated by the teachers include; require students to collect data of some sort, require students to hypothesize. To some extent, the teachers also used investigations, research reports, projects, constructed response essays, journals, and lab notebooks to assess students' science performance as indicated in the National Science Education Standards (NRC, 1996). The less practiced inquiry skills include; have students design their own experiments or investigations, and engage students in investigation or lab work (Table 14).

The themes that emerged from the qualitative data included experimentation and lab. Although the quantitative results indicated that about 73% of the teachers used experiments or investigation, this statement was corroborated by the qualitative results. During the interview, teachers talked about using experiments in their classrooms and the assessment of students' science performance based on their lab performance which is consistent with the specifications of the National Research Council (NRC, 1996). These triangulated data increased the trustworthiness or the validity of the study (See Table 14).

Table 14

Data Triangulation for Research Question 2

Research question	Quantitative Results of survey questions that support inquiry	Qualitative Results of structured interview themes
RQ-2 Assessment Methods How do inquiry-trained teachers assess student performance related to each of the five essential features of inquiry?	Hypothesis 4 •Require your students to make observations in class-81.82% •Require your students to take measurements in class-81.82% •Require your students to collect data of some -90.91% •Require your student to manipulate experimental materials providing a hands-on experience-81.82% •Have your students design their own experiments or investigations-63.64% •Engage students in investigations or lab work-72.73% •Require students to write up a lab report-61.90% •Require students to hypothesize-90.91% •Use experiments from the text or lab manual-77.27% •Have the students engage in an investigation on a topic before formally presenting the concepts in class-77.27% •Engage students in an investigation that takes more than one class period-72.27% •Investigations, research reports, projects-81.82% Hypothesis 5 •Engage students in constructed response, essays-81.82% Hypothesis 6 •Engage students to use Portfolios, journals, lab notebooks-81. 82%	1. Experiment 2. Lab

Research Question 3: Conclusions

What types of training experiences are essential to fully prepare elementary teachers to learn and apply science inquiry in their classrooms?

To address this research question, three hypotheses; hypotheses 7, 8 and 9 were proposed and tested quantitatively. Each hypothesis had one survey item question. Two of them were ranked highly; expert modeling and peer sharing were effective as indicated by 95% of the teachers. The less ranked professional development model was the focus group which received support from 90% of the teachers which is still high. In other words, the analysis of these hypotheses showed that the teachers approved the following conditions as indicators of effective training experiences required to prepare elementary teachers to learn and apply inquiry in their classrooms: expert modeling, peer sharing, and focus group discussion (See Table 15).

In the qualitative data analysis, teachers indicated that expert knowledge of the professional development professors was instrumental in their understanding of inquiry instruction. This supports the quantitative data. Some teachers indicated that both the content and pedagogical knowledge they gained increased their confidence to teach science and hence started teaching science to their students unlike in the past. As some of them indicated, teaching and learning of science is now an enjoyable experience to both teachers and students. Some of the teachers expressed delight on how their students' science retention and achievement have significantly improved as a result of science inquiry.

Other themes that came up were availability of kits now which came up as a strength and concern about kits in the future, insufficient time for science instruction which came up as a weakness and involving more or all teachers in future professional developments, which came up as a recommendation (See Table 15). Lack of kits and resources and insufficient time for science instruction have been expressed in other literature as barriers to inquiry implementation (Buczynski, S., & Hansen, B., 2010).

Table 15

Data Triangulation for Research Question 3

Research question	Quantitative Results of survey questions that support inquiry	Qualitative Results of structured interview themes
RQ-3 PD/Training What types of training experiences are essential to fully prepare teachers to learn and apply inquiry in their classrooms?	Hypothesis 7 • Experts modeling during PD was effective -95.24% Hypothesis 8 • Peer sharing during PD was effective-95.45% Hypothesis 9 • Focus group during PD was effective-90.48%	Strength: 1.Effective professors 2.Availability of kits Weakness: 3.Insufficient time for science Recommendation: 4. Involve more teachers in the program.

Implications

One implication of this study is that it would enable the schools, school district, and institutions of higher learning to learn from teachers' perspectives, the factors that promote or hinder inquiry-based instruction implementation by teachers in the classrooms. Some of the constraints that prevented teachers from the implementation of inquiry-based instruction included lack of science content knowledge, process knowledge, time constraints, funding, lack of support from administrators and No Child Left Behind (NCLB) legislation. Some teachers questioned why science is not tested at most grade levels in the elementary schools beside grade 5 during California Standards test. Though this has not been tested, teachers recommended that if science should be tested at most grade levels like mathematics and English language arts, then administrators would be forced to promote the teaching and learning of science, which would be potentially beneficial for the prosperity of the country especially at this difficult economic time. "History suggests that a nation that relinquishes the torch of science puts its future prosperity at risk and jeopardizes its place in the history of civilization" (National Science Board, 2004, p.1).

Another implication of the study is that it would help the districts and school administrators to learn the effective aspects of professional development that it could employ in future professional development series or training for teachers. The institution of higher education faculty will also benefit from this study by knowing and employing effective teaching strategies in their science methods classes.

Recommendations for Policy/Practice

The lessons learned in this study provided a context for recommendations that would support efforts to understand science education reform, and bring about quality science education programs that would improve the teaching and learning of science in grades 4-6 and possibly other elementary grade levels. The recommendations will target classroom teachers, professional development providers, school and district-based administrators and policy makers.

Teachers who have direct contact with students need to have a voice in all reform efforts in the schools. A lot of reform efforts in the schools take the form of top to bottom system of leadership, where decisions are usually made at the district offices and handed over to the teachers to implement. The researcher recommends that teachers should be included in all reform efforts in the schools. As a result, some teachers could be included as teacher leaders in inquiry professional development. These teacher leaders should be fully trained to be knowledgeable about inquiry lesson design and inquiry-based training that would enable them to model inquiry training through workshops to new and experienced teachers.

This study has highlighted factors of professional development trainings that were effective. Professional developers could integrate these factors into their science teaching methods courses for improved teachers' performance and subsequent students' performance.

School principals were not involved in this study. The researcher recommends that there should be a policy change to involve principals or designee in future inquiry-based training. This could be in the way of the principals attending some of the summer workshops and participating in the professional development activities or in the form of a meeting involving the principals and their teachers including professional developers where factors responsible for successful inquiry implantation would be discussed. This could help the principals and teachers to work together and make concerted efforts towards successful inquiry implementation.

As studies have shown, systematic and continuous professional development should be an ongoing process for the implementation of a new instructional strategy

(Guskey, 2000). Financial allocation by the district is of critical significance if professional development programs are to provide useful, relevant, and effective in service practices leading to meaningful outcomes on the professional growth of the science teachers, and significant improvements in classroom practice.

Policy makers should give science the priority it deserves. Teachers in this study called for science to be tested at all grades levels at the elementary schools. They asked why science is tested only in grade 5 at the elementary schools in California unlike English language arts and mathematics that is tested at all levels. I recommend that policy makers reform science instruction at the elementary level and give it the priority it deserves.

Recommendations for Further Studies

I recommend that a large sample size is used for the next study. This would make it possible to use statistical analysis that is prone to yielding statistically significant results as opposed to small sample size used in this study (Patten, 2005).

The data gathered for this study was based on teachers self-report after 18 months of inquiry-based training. A future study should include observations of participant teachers using a reliable and valid inquiry observation protocol. Multiple sources of data will increase the validity of the study. However, some studies have shown that when using an anonymous sample survey that teacher's self-reports of teaching practices are moderately to highly correlate with classroom observations and hence are a valid measure of their instruction (Mullens & Gayler, 1999; Mullens & Kasprzyk, 1996).

Summary

This mixed methods study was designed to describe the perceptions of elementary teachers from an urban school district in Southern California regarding their inquiry-based science instructional practices, assessment methods, and professional development. It did so by using three research questions to explore teachers' practices, assessment methods, and the effective aspects of the professional development they received. Data collected from the quantitative component clearly supported the practices of these teachers using inquiry as outlined in the National science Educational standards (NRC, 1996). Also the data collected clearly supported the assessment methods of these teachers as that of inquiry. In addition, data collected clearly supported expert modeling, peer sharing, and focus group discussions as the effective aspects of the professional development they received.

However, the qualitative component did support but not all the hypotheses tested in the quantitative component. Also, qualitative data collected indicated that a good number of teachers would have preferred to practice the strategy but unfortunately could not due to lack of time. Some teachers attributed non implementation to insufficient time to teach science that has been exacerbated by decreasing science instructional time to increase those of English language arts and mathematics.

In all, the teachers found the professional development to be meaningful and effective and would like to implement it. However due to high stakes tests, lack of administrators' support as a result of NCLB emphasis on Mathematics and ELA, reduction of science instructional time, and lack of funding, teacher implementation is short of expectation. It was sad to hear a teacher talk about hiding from the administrators to teach science as if teaching science is an abomination.

Inquiry-based science has been found to be beneficial to English language learners (Cuevas et al., 2005). It has been found to be beneficial to students with learning disabilities (Palincsar et al., 2001). A positive correlation has also been found to exist between FOSS-based kits and deaf education (Mangrubang, 2004).

This study has shown the negligence of science instruction in the elementary schools and the need for the reform of California educational policy to give science the priority it deserves. With the benefits of science inquiry instruction as indicated in previous studies and this study as well, the researcher calls on the policy makers to create a system structure to promote science inquiry instruction in the elementary schools. This would help to bridge the science achievement gaps as the strategy is beneficial to various student groups (Cuevas et al., 2005; Palincsar et al., 2001; Mangrubang, 2004). It would also help to produce science literate citizens who would be able to make informed decisions in their lives about science related issues. Science literate citizens will also create the knowledge base required to solve the local, national, and global problems related to science (NRC, 1996). Through science instruction the nation could produce individuals who would be able to make discoveries in science and utilize science discoveries to benefit human kind (Wilbraham et al., 2002).

As reported by the National Science Board (2004), “History suggests that a nation that relinquishes the torch of science puts is future prosperity at risk and jeopardizes its place in the history of civilization” (p. 1).

REFERENCES

Abadiano, H. R., & Turner, J. (2005). Reading fluency: The road to developing efficient and effective readers. *The NERA Journal, 41*(1), 50-56. Retrieved from http://www.google.com/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=1&ved=0CHQQFjAA&url=http%3A%2F%2Fwww.reading.ccsu.edu%2F6th_Year_Renewal%2FHelen%2520Portfolio%2FFiles%2FReading%2520Fluency-%2520The%2520Road%2520to%2520Developing.pdf&ei=XzjKT4rKFqre2AXlxYzaCw&usg=AFQjCNGYinUnynOU1T0orDgOO3B5s7YquQ&sig2=TTAsyxBP9Btdp-NyosVxaw

Akerson, V. L., & Hanuscin, D. L. (2007). Teaching nature of science through inquiry: Results of a 3 year professional development program. *Journal of Research in Science Teaching, 44*(5), 653-680. doi: 10.1002/tea.20159

American Association for the Advancement of Science. (AAAS). (1990). *Science for all Americans.* New York, NY: Oxford University Press.

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

American Psychological Association. Publication manual. (2010). Washington, DC: Author.

Ashton, P. T., & Webb, R. B. (1986). *Making a difference: Teachers' sense of efficacy and student achievement*. New York, NY: Longmans.

Baldi, S., Jin, Y., Skemer, M., Green, P., & Herget, D. (2007). *Highlights from PISA 2006. Performance of U.S. 15-year-old students in science and mathematics literacy in an international context (NCES, 2008-016*). Washington, DC: National

Center for Education Statistics, Institute of Education Services, U.S. Department of Education.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*, *84*(2), 191-215. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/847061

Barrow, L. (2006). A brief history of inquiry. From Dewey to standards. *Journal of Science Teacher Education, 17*, 265-278. doi: 10.1007/s10972-006-9008-5

Bikkar, R. S., Beamer, J. E., & Lundberg, I. (1993). Role of mathematics self-efficacy in the structural model of mathematics achievement. *Journal of Educational Psychology, 85(*1), 41-48. doi: 10.1037/0022-0663.85.1.41

Blank, R., & Engler, K. (1992). *Has science and mathematics education improved since "A Nation At Risk"? Trends in course enrollments, qualified teachers, and student achievement. Science and Mathematics Indicators Project*. Washington, DC: Council of Chief State School Officers, U.S. Department of Education.

Bredderman, T. (1983). Effect of activity-based elementary science on student outcomes. A qualitative synthesis. *Review of Educational Research*, *53*(4), 499-518. Retrieved fromhttp://www.jstor.org/discover/10.2307/1170219?uid=3739560&uid=2129&uid=2134&uid=2&uid=70&uid=4&uid=3739256&sid=47699059459167

Brouwer, N., & Korthagen, F. (2005). Can teacher education make a difference? *American Educational Research Journal, 42*(1), 153-224. doi: 10.3102/00028312042001153

Buczynski, S., & Hansen, B. (2010). Impact of professional development on teacher practice: Uncovering connections. *Journal of Teaching and Teacher Education 26*(3), 599-607. doi: 10.1016/j.tate.2009.09.006

Bybee, R. (2008). Scientific literacy, environmental issues, and PISA 2006: The 2008 Paul F-Brandwein Lecture. *Journal of Science Educational Technology*, *17*, 566-585. doi: 10.1007/s10956-008-9124-4

California Department of Education (2010). *Star results*. Retrieved from http://star.cde.ca.gov/

Chiappetta, E., & Fillman, D. (2007). Analysis of five high school biology textbooks used in the United States for inclusion of the nature of science. *International Journal of Science Education*, *29*(15), 1847-1868. doi: 10.1080/09500690601159407

Cohen-Vogel, L. (2005). Federal role in teacher quality: "Redefinition or policy alignment*?"* *Educational Policy*, *19*(1), 18-43. doi: 10.1177/0895904804272246

Coln, K. (2008). *The status of inquiry-based science instruction in a mid-size school district for grades 3-8 as mandated state-wide testing begins* (Doctoral dissertation). ProQuest Dissertations and Theses database. (AAT 3320937)

Creswell, J. (2007). *Qualitative inquiry and research design: Choosing among five approaches* (3rd ed.). Thousand Oaks, CA: Sage

Creswell, J. (2008). *Educational research: Planning, and conducting, and evaluating quantitative and qualitative research* (3rd ed.). Upper Saddle River, NJ: Merrill.

Creswell, J. (2009). *Research design. qualitative, quantitative, and mixed methods approaches*. Thousand Oaks, CA: Sage

Creswell, J., & Miller, D. (2000). Determining validity in qualitative inquiry. *Journal of Theory into practice,* 39(3), 124-130. doi: 10.1207/s15430421tip3903_2

Creswell, J., & Plano Clark, V. (2007). *Designing and conducting mixed methods research*. Thousand Oaks, CA: Sage.

Cuevas, P., Lee, O., Hart, J., & Deaktor, R. (2005). Improving science inquiry with elementary students of diverse backgrounds. *Journal of Research in Science Teaching, 42*(3), 337-357. doi: 10.1002/tea.20053

Dickerson, D., Clark, M., Dawkins, K., & Horne, C. (2006). Using science kits to construct content understanding in elementary schools. *Journal of Elementary Science Education, 18*(1), 43-56. Retrieved from http://www.google.com/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=1&ved=0CKQBEBYwAA&url=http%3A%2F%2Fwww.ecu.edu%2Fcs-educ%2Fcsmte%2Fupload%2Fscience_kits_construct_content.pdf&ei=yUDKT52gIHM2AXIrsjZCw&usg=AFQjCNFlgEoeRcsOqUeelM9xFqAWl8espw&sig2=6uUdKPgS6XSvtpQzb5JFAA

Dietz, C., & Davis, E. (2009). Preservice elementary teachers' reflection on narrative images of inquiry. *Journal of Science Teacher Education, 20*(3), 219-243. doi: 10.1007/s10972-009-9132-0

Enochs, L. G., Scharmann, L. C., & Riggs, I. M. (1995). The relationship of pupil control to pre-service elementary science teaching self-efficacy and outcome expectancy. *Science Teacher Education, 79*(1), 3-75. doi: 10.1002/sce.3730790105

Fleischman, H., Hopstock, P., Pelczar, M., & Shelley, B. (2010). *Highlights from PISA 2009: Performance of U.S. 15-year old students in reading, mathematics, and* *science literacy in an international context* (NCES 2011-004). U.S. Department of Education, National Center for Education Statistics. Washington, DC: Government Printing Office.

Fullan, M. (2006). *Turnaround leadership.* San Francisco, CA: Jossey-Bass.

Gallagher, S. (1994). Middle school classroom predictors of science persistence. *Journal of Research in Science Teaching*, *31*(7), 721-734. doi: 10.1002/tea.3660310705

Girod, M., & Twyman, T. (2009). Comparing the added value of blended science and literacy curricula to inquiry-based science curricula in two 2nd-grade classrooms. *Journal of Elementary Education*, *21*(3), 13-32. Retrieved from http://www.eric.ed.gov/contentdelivery/servlet/ERICServlet?accno=EJ849718

Griffith, G. (2008). Initial impacts of no child left behind on elementary science education. *Journal of Elementary Science Education*, *20*(3), 35-48. doi: 10.1007/BF03174707.

Grigg, W., Lauko, M., & Brockway, D. (2006). *The Nations' Report Card: Science 2005* (NCES 2006-466). U.S. Department of Education, National Center for Education Statistics, Washington, DC: Government Printing Office.

Guskey, T. (2000). *Evaluating professional development.* Thousand Oaks, CA: Corwin Press.

Harms, N., & Yager, R. (1981). *What research says to the science teacher* (Vol. 3). Washington, DC: National Science Teachers Association.

Houston, L., Fraser, B., & Ledbetter, C. (2008). An evaluation of elementary school science kits in terms of classroom environment and student attitudes. *Journal of Elementary Science Education*, *20*(4), 29-47. Retrieved from http://www.eric.ed.gov/ERICWebPortal/contentdelivery/servlet/ERICServlet?accno=ED476657

Inquiry and the National Science Education Standards. (2000). *A guide for teaching and learning.* Washington, DC: National Academy Press.

Johnson, C., Kahle, J., & Fargo, F. (2007). Effective teaching results increased science achievement for all students. *Science Education, 91*(3), 371-383. doi: 10.1002/sce.20195

Kanter, D., & Konstantopoulos, S. (2010). The impact of a project-based science curriculum on minority student achievement, attitudes, and careers: The effects of teacher content and pedagogical knowledge and inquiry-based practices. *Journal of Science Education 94*(5), 855-887. doi: 10.1002/sce.20391

Kelly, M., & Staver, J., (2004). A case study of one school system's adoption and implementation of an elementary science program. *Journal of Research in Science Teaching, 42*(1), 25-52. doi: 10.1002/tea.20043

Kratochvil, D., & Crawford, J. (1971*). Science curriculum improvement study developed by the science curriculum project*. University of California, Berkeley. Washington, DC: U.S. Department of Health, Education, and Welfare.

Kyle, W. C., Shymansky, J. A., & Alport, J. M. (1982). Alphabet soup science: A second look at the NSF-funded science curricula. *The Science Teacher, 49*(8), 49-53. Retrieved from http://www.eric.ed.gov/ERICWebPortal/search/detailmini.jsp?_nfpb=true&_&ERICExtSearch_SearchValue_0=EJ270283&ERICExtSearch_SearchType_0=no&accno=EJ270283

Lawson, A. (2008). What can development theory contribute to elementary science instruction? *Journal of Elementary Science Education*, *20*(4), 1-14. Retrieved from http://www.eric.ed.gov/contentdelivery/servlet/ERICServlet?accno =EJ849834

Lederman, N. (2003). Learning about inquiry. *Science & Children*, *40*(4), 8-10. Retrieved from http://www.iit.edu/csl/msed/faculty/lederman_norman.shtml

Lee, O., Hart, J., Cuevas, P., & Enders, C. (2004). Professional development in inquiry-based science for elementary teachers of diverse student groups. *Journal of Research in Science Teaching*, *41*(10), 1021-1043. doi: 10.1002/tea.20037

Liang, L., & Richard, G. (2009). Enhancing prospective teachers' science teaching efficacy beliefs through scaffolded, Student-directed inquiry. *Journal of Elementary Science Education, 21*(1), 51-66. Retrieved from http://www.eric.ed.gov/PDFS/EJ849710.pdf

Lopez, R., & Schultz, T. (2001). Two revolutions in K-8 science education. *Physics Today*, *54*(9), 44-49. doi: 10.1063/1.1420511

Lord, T., & Orkwiszewski, T. (2006). Moving from didactic to inquiry-based instruction. *The American Biology Teacher*, *68*(6), 342-345. doi: http://dx.doi.org/10.1662 /0002-7685(2006)68[342:DTIIIA]2.0.CO;2

Makang, D. (2003). Analysis of an inquiry-oriented inservice program in affecting science teaching practices (Doctoral dissertation). Retrieved from ProQuest Dissertations and Theses database. (AAT 3084509)

Mangrubang, F. (2004). Preparing elementary education majors to teach science using an inquiry-based approach: The full option science system. *American Annals of the Deaf, 149*(3), 290-303. Retrieved from http://web.ebscohost.com.lib. pepperdine.edu/ehost/pdfviewer/pdfviewer?sid=cd655328-ffbf-4a79-98a0-017290d2235f%40sessionmgr112&vid=4&hid=113

Mangrubang, F. (2005). Issues and trends in science education: The shortage of qualified science teachers. *American Annals of the Deaf, 150*(1), 42-46. doi: 10.1353/aad.2005.0019

Marvel, J., Lyter, D., Peltola, P., Strizek, G., & Morton, B. (2006). *Teacher attrition and mobility: Results from the 2004-05 Teacher Follow-up survey* (NCES, 2007-307). U.S. Department of Education, National Center for Education Statistics. Washington, DC: Government Printing Office.

Marx, R. W., & Harris, C. J. (2006). No child left behind and science education: Opportunities, challenges, and risks. *The Elementary School Journal, 106*(5), 455 -466. doi: 10.1086/505441

McCreight, C. (2000). Teacher attrition, shortage, and strategies for teacher retention. Retrieved from http://www.eric.ed.gov/PDFS/ED444986.pd

McNeill, J., Lips, D., Marshall, J., & Carafano, J. (2008). *Improving U.S. competitiveness with K-12 stem education and training: A report on the Stem Education and National Security Conference.* Retrieved from http://www.heritage.org /Research/Reports/2009/06/Improving-US-Competitiveness-with-K-12-STEM -Education-and-Training

Mitchell, C. (2007). *The use of two professional learning community practices in elementary classrooms and the English language arts achievement of California's most at risk student subgroups in a southern California school district*. (Doctoral dissertation). Retrieved from ProQuest Dissertations and Theses database. (AAT 3256104)

Mullens, J. E., & Gayler, K. (1999). *Measuring classroom instructional processes: Using survey and case study field test results to improve item construction* (NCES, 1999-2008). Washington, DC: National Center for Education Statistics.

Mullens, J. & Kasprzyk, D. (1996). *Using qualitative methods to validate quantitative survey instruments. In 1996 proceedings of the Section on Survey Research Methods* (p. 638-643). Alexandria, VA: American Statistical Association.

Naizer G., Bell, G., West, K., & Chambers, S. (2003). Inquiry science professional development combined with a science summer camp for immediate application. *Journal of Elementary Science Education, 15*(2), 31-37. Retrieved from http://www.eric.ed.gov/ERICWebPortal/contentdelivery/servlet/ERICServlet?accno=EJ852420

National Center for Education Statistics (NCES) (2000). *Highlights: The nation's report card (2000).* Washington, DC: U.S. Department of Education. Office of Education Research and Improvement.

National Center for Education Statistics (NCES) (2006). *The condition of education, 2006*. Retrieve from http://www.google.com/search?sourceid=navclient&ie=UTF-8&rlz=1T4ADFA_enUS412&q=Nces+2006

National Center for Education Statistics (NCES) (2007a). *Comparative indicators of education in the United States and other G-8 countries: 2006*. Washington, DC: U.S. Department of Education.

National Center for Education Statistics. (2007b). Teacher attrition and mobility: Results from the 2004-2005 teacher follow up survey. *Retrieved from* http://nces.ed.gov/pubsearch/index.asp?HasSearched=1&searchcat2=subjectindex&L1=2&L2=5

National Center for Education Statistics (NCES) (2010). *Digest of education statistics, 2010. Elementary/secondary education enrollment*: Retrieved from http://nces.ed.gov/programs/digest/d10/

National Commission on Excellence in Education. (1983). *A nation at risk*: *The imperative for educational reform.* Washington, DC: Government Printing Office.

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

National Research Council (NRC) (2000*). Inquiry and the national science education standards: A guide for teaching and learning*. Washington, DC: National Academy Press.

National Science Board. (2004). *Science and engineering indicators, 2004*. Arlington. VA: National Science Foundation. Retrieved from http://www.nsf.gov /statistics/seind04/

Newman, W., Abell, S., Hubbard, P., McDonald, J., Otaala, J., & Martini, M. (2004). Dilemma of teaching Inquiry in elementary science methods. *Journal of Science Teacher Education*, *15*(4), 257-279. doi: 10.1023/B:JSTE.0000048330.07586.d6

Nolasco, J. (2009). *Effects of Literature cirles on the comprehension of reading expository texts (*M.A.S.E dissertation). Retrieved from Dissertations and Theses. (AAT 1463936)

Oware, E. (2008). *Examining elementary students' perceptions of engineers* (Doctoral dissertation). Retrieved from ProQuest Dissertations and Theses database. (AAT 3344179)

Palincsar, A., Magnusson, S., Collins, K., & Cutter, J. (2001). Making science accessible to all: Results of a design experiment in inclusive classrooms. *Learning Disability Quarterly, 24*(1), 15-32. Retrieved from http://www.google.com/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=3&ved=0CFsQFjAC&url=http%3A%2F%2Fwww.catea.gatech.edu%2Fscitrain%2Fkb%2FFullText_Articles%2FPalinscar_Magnusson.pdf&ei=r_jKT6iLGaOM2gWT3aTaCw&usg=AFQjCNFVZRXdsYfAZBMv72H1spxnaIFNwA&sig2=7DawPdLZwxDlHcjjmQEluw

Patten, M. (2005) *Proposing empirical research. A guide to the fundamentals*. Glendale, CA: Pyrczk.

Pine, J., Aschbacher, P., Roth, E., Jones, M., McPhee, C., Martin, C., & Foley, B. (2006). Fifth graders' science inquiry abilities: A comparative study of students in hands-on and textbook curricula. *Journal of Research in Science Teaching, 43*(5), 467–484. doi: 10.1002/tea.20140

Richardson, G., & Liang, L., (2008). The use of inquiry in the development of pre-service teacher efficacy in mathematics and science. *Journal of Elementary Science Education, 20*(1), 1-16. http://www.eric.ed.gov/PDFS/EJ798565.pdf

Rosebery, A., & Warren, B. (2008). *Teaching science to English learners: Building on students' strengths*. Arlington, VA: National Science Teachers Association.

Ruiz-Primo, M., Tsai, M., & Schneider, J. (2010). Testing one premise of scientific inquiry in science classrooms: Examining students' Scientific Explanations and

Student Learning. *Journal of Research in Science Teaching, 47*(5), 583-608. doi: 10.1002/tea.20356

Saks, A. L. (2005). Teams-BC and the nature of Collaboration: An analysis of the effectiveness of collaboration in the design and implementation of systemic reform (Doctoral dissertation). Retrieved from ProQuest Dissertations and Theses database. (AAT 3196237)

Sandall, B. (2003). Elementary science: Where are we now? *Journal of Elementary Science Education*, *15*(2), 13-30. Retrieved from http://www.eric.ed.gov /contentdelivery/servlet/ERICServlet?accno=EJ852419

Scott, A., Dittmer, K., Fiasca, M. (1967). Biology-chemistry-physics. A three year sequence. Washington, DC: U.S. Department of Health, Education & Welfare.

Schroeder, C. M., Scott, T. P., Tolson, H., Huang, T. Y., & Lee, Y. H. (2007). A meta-analysis of national research: Effects of teaching strategies on student achievement in science in the United States. *Journal of Research in Science Teaching, 44*(10), 1436-1460. doi: 10.1002/tea.20212

Shen, J., Gerard, L., & Bowyer, J. (2009). Getting from here to there: The roles of policy makers and principals in increasing science teacher quality. *Journal of Science Teacher Education, 21*(3), 283-307. doi 10.1007/s10972-009-9180-5

Staver, J., & Bay, M. (1987). Analysis of the project synthesis goal cluster orientation and Inquiry emphasis of elementary science textbooks. *Journal of Research in Science Teaching, 24*(7), 629-643. doi: 10.1002/tea.3660240704

Staver, J., & Wang. J. (2001). Examining relationships between factors of science education and student career aspirations. *The Journal of Educational Research, 94(*5), 312-319. Retrieved from http://www.jstor.org/discover/10.2307 /27542339?uid=3739560&uid=2129&uid=2134&uid=2&uid=70&uid=4&uid=3739256&sid=47699059381017

U.S. Department of Education. (2000). *Before it is too late: A report to the nation from the national commission on mathematics and science teaching for the 21st century*. Retrieved from http://www.ed.gov/americounts/glenn.doc

U.S. Department of Education (2005). Institute of Education Sciences. National Center for Education Statistics. National Assessment of Educational Progress (NAEP), 2005 Science Assessment.

Wallace, C., & Kang, N. (2004). An investigation of experienced secondary science teachers' beliefs about inquiry: An examination of competing belief sets. *Journal of Research in Science Teaching, 42* (9), 936-960. doi: 10.1002/tea.20032

Wee, B., Shepardson, D., Fast, J., & Harbor, J. (2007). Teaching and learning about inquiry: Insights and challenges in professional development. *Journal of Science Teacher Education 18*(1), 63-89. doi: 10.1007/s10972-006-9031-6

Wilbraham, A., Staley, D., Matta, M., & Waterman., E. (2002). *Chemistry*. Saddle River, NJ: Addison-Wesley.

Willoughby, J. (2004). *The effect of an enriched learning community on success and retention in chemistry courses* (Doctoral dissertation). Retrieved from ProQuest Dissertations and Theses database. (AAT 3165148)

Wood, A., & Stanulis, R., (2009). Quality teacher induction: “Fourth-Wave” (1997-2006) induction programs. *The New Educator, 5*(1), 1-23. Retrieved from http://www.eric.ed.gov/contentdelivery/servlet/ERICServlet?accno=EJ868911

APPENDIX A

Pepperdine IRB Approval

Graduate & Professional Schools Institutional Review Board

November 1, 2011

Protocol #: E1011D05
Project Title: Perceived Effectiveness Of An Inquiry-Based Science Professional Development On Elementary Students' Science Achievement In An Urban School District In Southern California

Dear Mr. Ugwu:

Thank you for submitting the revisions requested by Pepperdine University's Graduate and Professional Schools IRB (GPS IRB) for your study, Perceived Effectiveness Of An Inquiry-Based Science Professional Development On Elementary Students' Science Achievement In An Urban School District In Southern California. The IRB has reviewed your revisions and found them acceptable. You may proceed with your study. The IRB has determined that the above entitled project meets the requirements for exemption under the federal regulations 45 CFR 46 - http://www.nihtraining.com/ohsrsite/guidelines/45cfr46.html that govern the protections of human subjects. Specifically, section 45 CFR 46.101(b) (2) states:

> (b) Unless otherwise required by Department or Agency heads, research activities in which the only involvement of human subjects will be in one or more of the following categories are exempt from this policy:
>
> **Category (2) of 45 CFR 46.101**, research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: a) Information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and b) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

Your research must be conducted according to the proposal that was submitted to the IRB. If changes to the approved protocol occur, a revised protocol must be reviewed and approved by the IRB before implementation. For any proposed changes in your research protocol, please submit a **Request for Modification Form** to the GPS IRB. Because your study falls under exemption, there is no requirement for continuing IRB review of your project. Please be aware that changes to your protocol may prevent the research from qualifying for exemption from 45 CFR 46.101 and require submission of a new IRB application or other materials to the GPS IRB.

A goal of the IRB is to prevent negative occurrences during any research study. However, despite our best intent, unforeseen circumstances or events may arise during the research. If an unexpected situation or adverse event happens during your investigation, please notify the GPS IRB as soon as possible. We will ask for a complete explanation of the event and your response. Other actions also may be required depending on the nature of the event. Details regarding the timeframe in which adverse events must be reported to the GPS IRB and the appropriate form to be used to report this information can be found in the *Pepperdine University Protection of Human Participants in Research: Policies and Procedures Manual* (see link to "policy material" at http://www.pepperdine.edu/irb/graduate/).

6100 Center Drive, Los Angeles, California 90045 ▪ 310-568-5600

Please refer to the protocol number denoted above in all further communication or correspondence related to this approval. Should you have additional questions, please contact me. On behalf of the GPS IRB, I wish you success in this scholarly pursuit.

Sincerely,

Jean Kang, CIP
Manager, GPS IRB & Dissertation Support
Pepperdine University
Graduate School of Education & Psychology
6100 Center Dr. 5th Floor
Los Angeles, CA 90045
jean.kang@pepperdine.edu
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APPENDIX B

IRB Certification

Certificate of Completion

The National Institutes of Health (NIH) Office of Extramural Research certifies that **Romanus Ugwu** successfully completed the NIH Web-based training course “Protecting Human Research Participants”.

Date of completion: 03/14/2011

Certification Number: 653434

APPENDIX C

Permission to Use Survey Instrument

Good luck to you in your process. I'm fine with you using my instrument. Will you cite use of it with modifications in your study? If so, I would ask that once you finish you send me a copy of your study so I can have it for reference as this is very much an area of passion for me.

Kecia

From: romanus Ugwu [email]
Sent: Friday, July 15, 2011 10:56 AM
To: Kecia Coln
Subject: Permission to use your dissertation survey instrument

Dear Dr. Coln,

I would like to begin by congratulating you for completing your doctoral degree.

I am a doctoral student at Pepperdine University in Los Angeles, CA. I found your 2008 dissertation instrument very useful to my study. Please would you kindly permit me to use it? If you do, I will do some modifications to capture certain elements of my research questions.

Thank you Doctor Coln and have a great day.

Sincerely,
Romy

APPENDIX D

Teacher Informed Consent

Participant (print):____
Principal Investigator (PI): Romanus Ugwu
Title of Project: The purpose of this proposed research is to describe the perceptions of elementary teachers from an urban school district in Southern California regarding their inquiry-based science instructional practices, assessment methods, and professional development.

1. I____, agree to participate in the research study under the direction of Dr. Robert Barner, Dr. Linda Purrington, and Dr. Joan Millsbuffehr . I understand that while the study will be under the supervision of Dr. Barner, Dr. Purrington and Dr. Millsbuffehr, other personnel who work with them may be designated to assist or act on their behalf.

2. The overall purpose of this research is to describe the perceptions of elementary teachers from an urban school district in Southern California regarding their inquiry-based science instructional practices, assessment methods, and professional development. The study will help to shed light on the practices of teachers who participated in the District's California Mathematics and Science Partnership (CaMSP) project in 2008-2009 and 2009-2010 school years. In addition it will help to delineate the aspects of the CaMSP professional development activities that were effective.

3. Your participation will involve the following: Subjects are required to complete, sign and return this form to Romanus Ugwu to acknowledge their agreement to participate in this study. Subjects are required to complete an online teacher survey and participate in a teacher interview which will be audio taped. Participants will not be required to state their names during the audio tape. The tapes will be destroyed after the study.

4. Completing the online survey questions will take approximately 15-20 minutes. The survey questions will be completed as soon as teachers sign the informed consent.

5. The potential benefits are (1) from the findings of this research, teachers can examine their inquiry instructional method. (2) The findings will help teachers to reevaluate their assessment practices. (3) The findings will shed light on the effective aspects of professional development for improved teacher practices and students' achievement.

6. There are potential risks and discomforts that might be associated with this research. While the risks are minimal, some anxiety or discomfort may result from teachers' confidentiality being compromised, possible boredom, fatigue, and/or slight discomfort from reflecting on the training that ended a year ago. In order to safeguard participants' confidentiality, no participant will be asked to identify him/herself or affix his/her name or any other identifying information on the survey. The PI will maintain the confidentiality of all participants. The analysis of the online teacher survey will be saved in a password protected computer accessible only to the researcher. The answers to the interview questions and its analysis will be locked in a cabinet accessible only to the researcher.

7. I understand that participation is voluntary and that I may refuse to participate and/or withdraw from the research at any time without penalty or loss of benefits to which I am otherwise entitled. I also understand that I am not obligated to answer all questions.

8. I understand that the investigator(s) will take all reasonable measures to protect the confidentiality of my records and my identity will not be revealed in any publication that may result from this project. The confidentiality of my records will be maintained in accordance with applicable state and federal laws.

9. I understand that the investigator is willing to answer any inquiries I may have concerning the research. I understand that I may contact the dissertation chair, Robert Barner, Ph.D at (310) 810-1737 if I have other questions or concerns about this study. I understand that if I have any questions about my rights as a research participant, I can contact Dr. Jean Kang, (IRB) Chair person, at (310) 568-2389.

10. I have read this consent form in its entirety and understand its content. I hereby consent to participate in the research described above.

____
Participant's Signature

____
Date

APPENDIX E

Teacher Survey

As an educator, your responses to this survey are extremely valuable. Thank you for participating in this survey. The survey takes approximately 20minutes to complete. You are a volunteer and you may choose to stop at any time. However, your responses would be beneficial in understanding the usefulness of inquiry-based training. All responses are anonymous. Please answer the questions openly and honestly.

TEACHER PRACTICE

1. Select one option in each question below. Over the course of an instructional unit, how often do you:					
	Never	Seldom	Some times	Oft en	Al wa ys
a. Lecture in class?					
b. Have students pose questions?					
c. Have the students sitting passively taking notes?					
d. Require your students to make observations in class?					
e. Require your students to take measurements in class?					
f. Require your students to collect data of some sort?					
g. Require your student to manipulate experimental materials providing a hands-on experience?					
h. Have your students design their own experiments or investigations?					
i. Engage students in investigations or lab work?					
j. Require your students to write up a lab report?					
2. Select one option in each question below. Over the course of an instructional unit, how often do you:					
a. Assess your students' prior knowledge?					
b. Use questions to probe students' understandings?					
c. Have your students read the chapter in their science textbook and answer the questions contained in their chapter or at the end of the chapter?					
d. Use the inquiry approach in the classroom?					
e. Require your students to make inferences					

from their observations?					
f. Require your students to hypothesize?					
g. Require your student to organize data on their own?					
h. Help the students use their data and observations to construct an understanding of the concepts being taught?					
i. Require your students to analyze data?					
j. Require your student to draw conclusions from the data they collected?					
3. Over the course of an instructional unit, how often do you:					
a. Give a direct answer to all of the students' questions?					
b. Become a co-learner with the students when investigating a topic or concept?					
c. Have students work in collaborative groups on an investigation?					
d. Use experiments from the text or lab manual?					
e. Follow-up a class presentation on a concept with a lab experiment?					
f. Have the students engage in an investigation on a topic before formally presenting the concepts in class					
g. Revise experiments from the text or a lab manual to make them more open-ended?					
h. Engage students in an investigation that takes more than one class period					
i. Have students use their experience in an investigation to help them answer their questions?					

4. What variations do you use in the classroom when teaching science to address #1 (Learner engages in scientifically oriented questions) of the 5 essential features of inquiry? Check one.

	Never	Seldom	Sometimes	Often	Always
a. Learner engages in scientifically oriented questions					
b. Learner selects among questions, poses new questions					
c. Learner poses a question					

d. Learner sharpens or clarifies question provided by teacher, materials, or other sources					
e. Learner engages in question provided by teacher, materials, or other source					

5. What variations do you use in the classroom when teaching science to address #2 (Learner gives priority to **evidence** in responding to questions) of the five essential features of inquiry? Check one.

	Never	Seldom	Sometimes	Often	Always
a. Learner gives priority to evidence in responding to questions					
b. Learner determines what constitutes evidence and collects it					
c. Learner is directed to collect certain data					
d. Learner is given data and asked to analyze					
e. Learner is given data and told how to analyze					

6. What variation do you use in the classroom when teaching science to address #3 (Learner formulates **explanations** from evidence) of the 5 essential features of inquiry? Check one.

	Never	Seldom	Sometimes	Often	Always
a. Learner formulates explanations from evidence					
b. Learner formulates explanation after summarizing evidence					
c. Learner is guided in the process of formulating explanations from evidence					
d. Learner is given possible ways to use evidence to formulate explanation					

e. Learner is provided with evidence					

7. What variation do you use in the classroom when teaching science to address #4 (Learner connects explanations to scientific knowledge) of the 5 essential features of inquiry? Check one.

	Never	Seldom	Sometimes	Often	Always
a. Learner connects explanations to scientific knowledge					
b. Learner independently examines other resources and forms the links to explanations					
c. Learner is directed toward areas and sources of scientific knowledge					
d. Learner is given possible connection					

8. What variation do you use in the classroom when teaching science to address #5 (Learner communicates and justifies explanations) of the five essential features of inquiry? Check one.

	Never	Seldom	Sometimes	Often	Always
a. Learner communicates and justifies explanations					
b. Learner forms reasonable and logical argument to communicate explanation					
c. Learner is coached in development of communication					
d. Learner is provided broad guidelines to use to sharpen communication					
e. Learner is given steps and procedures for communication					

ASSESSMENT OF STUDENT LEARNING

9. What type of assessment do you use in your inquiry-lessons? Check all that apply.

	Never	Seldom	Sometimes	Often	Always

a. Multiple choice, true or false, matching					
b. Constructed response, essays					
c. Investigations, research reports, projects					
d. Portfolios, journals, lab notebooks					
e. Anecdotal note assessment					
f. Conferencing					

TEACHER TRAINING

10. How will you assess the following? Check one.

	Excellent	Very good	Good	Poor	Very poor
a. Your understanding of the five essential features of inquiry?					
b. Overall, success in teaching science to your students?					
c. Success in using the inquiry method					
d. Students success in science					

11. How would you assess the effectiveness of the following Professional Development activities? Check one.

	Outstanding	Very Effective	Effective	Ineffectiv e	Very ineffective
a. Experts modeling					
b. Peer sharing					
c. Cooperative learning					
d. Focus group					
e. Reflective Practice					

:

12. What is your gender?

- Female
- Male

I3. Including 2010-2011 school year, how many years have you taught science?

- 0-3 years
- 4-6 years
- 7-9 years
- 13-15 years
- 16 or more years

14. Which grades are you currently teaching science? If you are currently teaching more than one grade level, mark all grade levels in which you are currently teaching science.

- 3
- 4
- 5
- 6

15. Are you certified in California to teach science in your current grade level(s)?

- No
- Yes

16. Are you “highly qualified” (HQ) by California standards to teach science at your grade(s)?

- No

- Yes

17. What is the average enrollment of your science classes?

- 1-15
- 16-20
- 21-25
- 26-30
- More than 30

18. Are you National Board Certified in science?

- No
- Yes

19. Was teaching by inquiry covered in any of your professional education courses?

- Covered in Bachelors course work
- Covered in Master course work
- Covered in Advanced Degree of Doctoral course work
- Covered in Certification Program for teachers' credentialing
- Inquiry was not covered in any of my education classes

20. Before the CaMSP project, have you ever attended a professional development workshop or institute at any level (ie district, regional, state, and/or national) that covered or discussed teaching by inquiry?

- No

- ○ Yes, I have attended one professional development workshop that discussed inquiry

- ○ Yes, I have attended two or more professional development workshops or institutes that discussed inquiry

APPENDIX F

Teacher Interview Protocol

1. How do you apply the five essential features of science inquiry in your classroom?

   ____

   ____

2. Describe the instructional method (or the process) you use in teaching science topics.

   ____

3. How do you assess your students’ science performance?

   ____

4. How do you assess the five essential features of science inquiry?

   ____

5. What is your perception about the CaMSP professional development? What do you perceive to be its strengths and weaknesses?____

   ____

6. What recommendations do you have in terms of the ideal training program for preparing elementary teachers to successfully implement inquiry in their classrooms? How and why will this recommendation(s) be useful?

   ____

APPENDIX G

Permission to Conduct Study

TO: Mr. Paul Gothold
From: Romanus Ugwu
Date: September 29, 2011
SUBJECT: Superintendent or Designee Permission to Conduct Study

I would like your permission to conduct a research study at Lynwood Unified School District as part of my doctoral dissertation at Pepperdine University. I am researching teachers that participated in the district's inquiry-based project, California Mathematics and Science Project (CaMSP) from 2008 to 2010 school years.

The purpose of this mixed methods study is to describe the perceptions of elementary teachers from an urban school district in Southern California regarding their inquiry-based science instructional practices, assessment methods, and professional development.

. The study will examine the following; teacher practices or lack thereof of the inquiry-based professional development they received from 2008-2010, teachers' assessment methods as a result of the new strategy and the effective aspects of the professional development activities they received.

The study will focus on the 33 teachers from the 12 elementary schools that participated in the district's CaMSP project. These 33 teachers will be invited to participate in the study. Participation is strictly voluntary. The findings of this study will be beneficial to the district and to other schools striving to implement effective inquiry-based professional developments.

Your district's participation in the study will contribute to knowledge and practices surrounding why teachers implement or fail to implement a new instructional strategy. It would also help to determine if teachers adopt new assessment methods as required by inquiry-based instruction. In addition, it would help to determine the effective aspects of the professional development that would be beneficial to the district for future teacher training.

Teachers who volunteer to participate will take an online survey for approximately 20 minutes. Also, an interview will be administered to the teachers which will take about 10 minutes. The interview will take place in person at the convenience of the teachers. I will tape record the interviews and transcribe the notes to ensure accuracy. Participant's identities will remain confidential and the interview notes and recordings will not be shared with others except with the statistician who will work with me to identify the themes and analyze the data. The interview notes will be examined for common themes and used to identify teachers' perceptions of practices that contribute to sustainable growth.

Participants who decide to participate are free to withdraw their consent or discontinue participation at any time. A copy of the informed consent and the interview protocol are attached for your information.

If you have any additional questions or concerns regarding this study, you may also contact my supervisor Dr. Robert Barner at Pepperdine University. Your signature indicates that you have read and understood the information provided above, that you willingly agree for me to conduct my study in Lynwood Unified school district, and that you have received a copy of this form.

Respectfully,

Romanus Ugwu

Romanus Ugwu

Attachments:

- Informed Consent for Participation in Research Activities
- Teacher Survey
- Teacher Interview Protocol and Questions.

I hereby consent to my school district's participation in this research described above.

Superintendent or Designee Signature

PAUL GOTHOLD

Please Print Superintendent or Designee's Name

10/7/11

Date

APPENDIX H

Faculty Supervisor Review Form

By my signature as a supervisor/sponsor on this research application, I certify that Romanus Ugwu (*insert name of the student or guest investigator*) is knowledgeable about the regulations and policies governing research with human subjects and has sufficient training and experience to conduct this particular study. The purpose of this study is to describe the perceptions of elementary teachers from an urban school district in Southern California regarding their inquiry-based science instructional practices, assessment methods, and professional development. (*insert title of study*) in accord with the proposed application and protocol. In addition,

- I have reviewed this application;
- I agree to meet with the investigator on a regular basis to monitor study progress;
- I agree to be available, personally, to supervise the investigator in solving problems should they arise during the course of the study;
- I assure that the investigator will promptly report significant or untoward adverse effects to the Pepperdine IRB chairperson in writing in accordance with the guidelines stated in Section III G of the Investigator's manual; and
- If I will be unavailable (e.g., sabbatical leave or vacation), I will arrange for an alternate faculty supervisor/sponsor to assume responsibility during my absence, and I will advise the IRB chairperson in writing of such arrangements.

______________________________________ _______________

Faculty Supervisor Signature **Date**

Robert Barner, Ph. D.
(Type Name**)**

APPENDIX I

Comparison of Borrowed Survey and Current Study Survey

	Survey questions	Borrowed survey (Used indicated question)	Current study Survey (Used indicated question)	Modifications
1	How often do teachers Lecture in class?	Yes	Yes	None
2	How often do teachers have students pose questions?	Yes	Yes	None
3	How often do teachers have students sitting passively taking notes?	Yes	Yes	None
4	How often do teachers require students to make observations in class?	Yes	Yes	None
5	How often do teachers require students to take measurements in class?	Yes	Yes	None
6	How often do teachers require students to collect data of some sort?	Yes	Yes	None
7	How often do teachers require student to manipulate experimental materials providing a hands-on experience?	Yes	Yes	None
7	How often do teachers require student to manipulate experimental materials providing a hands-on experience?	Yes	Yes	None
8	How often do teachers have students design their own experiments or investigations?	Yes	Yes	None
9	How often do teachers engage students in investigations or lab work?	Yes	Yes	None
10	How often do teachers require students to write up a lab report?	Yes	Yes	None
11	How often do teachers assess students’ prior knowledge?	Yes	Yes	None

12	How often do teachers use questions to probe students' understandings?	Yes	Yes	None
13	How often do teachers have students read the chapter in their science textbook and answer the questions contained in their chapter or at the end of the chapter?	Yes	Yes	None
14	How often do teachers use the inquiry approach in the classroom?	Yes	Yes	None
15	How often do teachers require students to make inferences from their observations?	Yes	Yes	None
16	How often do teachers require students to hypothesize?	Yes	Yes	None
17	How often do teachers require student to organize data on their own?	Yes	Yes	None
18	How often do teachers help the students use their data and observations to construct an understanding of the concepts being taught?	Yes	Yes	None
19	How often do teachers require students to analyze data?	Yes	Yes	None
20	How often do teachers require student to draw conclusions from the data they collected?	Yes	Yes	None
21	How often do teachers give a direct answer to all of the students' questions?	Yes	Yes	None
22	How often do teachers become co-learners with the students when investigating a topic or concept?	Yes	Yes	None
23	How often do teachers have students work in collaborative groups on an investigation?	Yes	Yes	None
24	How often do teachers use experiments from the text or lab manual?	Yes	Yes	None
25	How often do teachers, follow-up a class presentation on a concept with a lab experiment?	Yes	Yes	None
26	How often do teachers have the students engage in an investigation on a topic before formally presenting the concepts in class	Yes	Yes	N one

27	How often do teachers revise experiments from the text or a lab manual to make them more open-ended?	Yes	Yes	None
28	How often do teachers Engage students in an investigation that takes more than one class period	Yes	Yes	None
29	How often do teachers have students use their experience in an investigation to help them answer their questions?	Yes	Yes	None
30	Learner engages in scientifically oriented questions?	No	Yes	Question added in current study to test a hypothesis not tested by the borrowed survey.
31	Learner selects among questions, poses new questions?	No	Yes	Question added in current study to test a hypothesis not tested by the borrowed survey.
32	Learner poses a question?	No	Yes	Question added in current study to test a hypothesis not tested by the borrowed survey.
33	Learner sharpens or clarifies question provided by teacher, materials, or other sources?	No	Yes	Question added in current study to test a hypothesis not tested by the borrowed survey.
34	Learner engages in question provided by teacher, materials, or other source?	No	Yes	Question added in current study to test a hypothesis not tested by the borrowed survey.
35	Learner gives priority to evidence in responding to questions?	No	Yes	Question added in current study to test a hypothesis not tested by the borrowed survey.
36	Learner determines what constitutes evidence and collects it?	No	Yes	Question added in current study to test a hypothesis not tested by the borrowed survey.

37	Learner is directed to collect certain data?	No	Yes	Question added in current study to test a hypothesis not tested by the borrowed survey.
38	Learner is given data and asked to analyze?	No	Yes	Question added in current study to test a hypothesis not tested by the borrowed survey.
39	Learner is given data and told how to analyze?	No	Yes	Question added in current study to test a hypothesis not tested by the borrowed survey.
40	Learner formulates explanations from evidence?	No	Yes	Question added in current study to test a hypothesis not tested by the borrowed survey.
41	Learner formulates explanation after summarizing evidence?	No	Yes	Question added in current study to test a hypothesis not tested by the borrowed survey.
42	Learner is guided in the process of formulating explanations from evidence?	No	Yes	Question added in current study to test a hypothesis not tested by the borrowed survey.
43	Learner is given possible ways to use evidence to formulate explanation?	No	Yes	Question added in current study to test a hypothesis not tested by the borrowed survey.
44	Learner is provided with evidence?	No	Yes	Question added in current study to test a hypothesis not tested by the borrowed survey.
45	Learner connects explanations to scientific knowledge?	No	Yes	Question added in current study to test a hypothesis not tested by the borrowed survey.
46	Learner independently examines other resources and forms the links to explanations?	No	Yes	Question added in current study to test a hypothesis not tested by the borrowed survey.

47	Learner is directed toward areas and sources of scientific knowledge?	No	Yes	Question added in current study to test a hypothesis not tested by the borrowed survey.
48	Learner is given possible connection?	No	Yes	Question added in current study to test a hypothesis not tested by the borrowed survey.
49	Learner communicates and justifies explanations?	No	Yes	Question added in current study to test a hypothesis not tested by the borrowed survey.
50	Learner forms reasonable and logical argument to communicate explanation?	No	Yes	Question added in current study to test a hypothesis not tested by the borrowed survey.
51	Learner is coached in development of communication?	No	Yes	Question added in current study to test a hypothesis not tested by the borrowed survey.
52	Learner is provided broad guidelines to use to sharpen communication?	No	Yes	Question added in current study to test a hypothesis not tested by the borrowed survey.
53	Learner is given steps and procedures for communication?	No	Yes	Question added in current study to test a hypothesis not tested by the borrowed survey.
54	Teacher uses multiple choice, true or false, matching as assessment?	No	Yes	Question added in current study to test a hypothesis not tested by the borrowed survey.
55	Teacher uses constructed response, essays as assessment?	No	Yes	Question added in current study to test a hypothesis not tested by the borrowed survey.
56	Teacher uses investigations, research reports, projects as assessment?	No	Yes	Question added in current study to test a hypothesis not tested by the borrowed survey.
57	Teacher uses portfolios, journals, lab notebooks as assessment?	No	Yes	Question added in current study to test a hypothesis not tested by the borrowed survey.

58	Teacher uses anecdotal note as assessment?	No	Yes	Question added in current study to test a hypothesis not tested by the borrowed survey.
59	Teacher uses conferencing as assessment?	No	Yes	Question added in current study to test a hypothesis not tested by the borrowed survey.
60	Teachers' self-assessment of their understanding of the five essential features of inquiry?	No	Yes	Question added in current study to test a hypothesis not tested by the borrowed survey.
61	Teachers' self-assessment of their overall, success in teaching science to your students?	No	Yes	Question added in current study to test a hypothesis not tested by the borrowed survey.
62	Teachers' self-assessment of their success in using the inquiry method?	No	Yes	Question added in current study to test a hypothesis not tested by the borrowed survey.
63	Teachers' self-assessment of their students' success in science?	No	Yes	Question added in current study to test a hypothesis not tested by the borrowed survey.
64	Teachers' assessment of expert modeling of the professional development?	No	Yes	Question added in current study to test a hypothesis not tested by the borrowed survey.
65	Teachers' assessment of peer sharing of the professional development?	No	Yes	Question added in current study to test a hypothesis not tested by the borrowed survey.
66	Teachers' assessment of cooperative learning of the professional development?	No	Yes	Question added in current study to test a hypothesis not tested by the borrowed survey.
67	Teachers' assessment of Focus group of the professional development?	No	Yes	Question added in current study to test a hypothesis not tested by the borrowed survey.
68	Teachers' assessment of Reflective Practice of the professional development?	No	Yes	Question added in current study to test a hypothesis not tested by the borrowed survey.

69	Prior to the 2007-08 school year when North Carolina began the new operational science End of Grade (EOG) test, how often did you use inquiry when teaching your science classes?	Yes	No	Not addressed in current survey
70	To what extent has the implementation of science End of Grade (EOG) testing impacted your instruction?	Yes	No	Addressed by questions 4, 5, 6, 7, and 8 of current survey
71	Explain how your teaching has or has not changed since the implementation of science End of Grade (EOG) tests. (Please type your answer in the text below	Yes	No	Addressed by questions 4, 5, 6, 7, and 8 of current survey
72	Considering all the instructional methodologies you use in your classroom, which one do you use most and why? (Please type you answer in the text box below)	Yes	No	Addressed by questions 4, 5, 6, 7, and 8 of current survey
73	Have you experienced any barriers or constraints in planning your ideal science instruction?	Yes	No	Not addressed in current survey
74	If yes, please identify your ideal science instruction methodology and explain or list some of the barriers or constraints encountered	Yes	No	Not required in current study, designed for quantitative responses only
75	What is your gender?	Yes	Yes	None
76	Including this school year, how many years have you taught science?	Yes	Yes	None
77	Which grades are you currently teaching science? If you are currently teaching more than one grade level, mark all grade levels in which you are currently teaching science.	Yes	Yes	None

78	Are you certified to teach science in your current grade level(s)? Are you "highly qualified" (HQ) by California standards to teach science at your grade(s)?	Yes	Yes	None
79	What is the average enrollment of your science classes?	Yes	Yes	None
80	Are you National Board Certified in science?	Yes	Yes	None
81	Was teaching by inquiry covered in any of your professional education courses?	Yes	Yes	None
82	Have you ever attended a professional development workshop or institute at any level (ie district, regional, state, and/or national) that covered or discussed teaching by inquiry?	Yes	Yes	20. Before the CaMSP project, have you ever attended a professional development workshop or institute at any level (ie district, regional, state, and/or national) that covered or discussed teaching by inquiry?

APPENDIX J

Interview Summary

Teacher	Grade	School	Gender	Experience	RQ1(IQ 1, 2): 1. How do you apply the five essential features of inquiry in your classroom? 2. How do you regularly teach science topics to your students (your instructional process) (TEACHER PRACTICE)	RQ 2 (IQ3, 4): 1. How do you assess your students' science performance? 2. How do you assess the five essential features of science inquiry? (ASSESSMENT METHODS)	RQ 3(IQ 5, 6): 1. What is your perception of the CaMSP professional development? What do you perceive to be its strengths and weaknesses? 2. What recommendations do you have in terms of the ideal training program for preparing elementary teachers to successfully implement inquiry in their class? How and why will this recommendation(s) be useful (PD/TRAINING)
Teacher 01	4/5/6	A	Female	12	Questioning Discussion experiment Tap into prior knowledge Actively involved Identify/clarify misconceptions	Class participant Projects Group participant Paper/pencil Using pictures Level of participation Student interest	Hands on Different forms of experiments for different student population Have PD in advance before school Starts
Teacher 02	4	B	Male	15	Actively involved Questioning exploration Explanation Experimentation Tap into prior knowledge Engagement Exploration Explanation	Recount what was learned Explanation of lesson learned to someone else Multiple choice Open-ended questions Use of grading rubrics Explanation of procedures Explanation of observations Explanation of lesson learned	Builds confidence in Science Instruction Show steps by step procedure Downloaded lessons were helpful Involve all staff

Teacher 03	6	B	Male	13	Actively involved Hands on approach Lab report Multiple choice assessment Open-ended questions Tap into prior knowledge Questioning Discussion	Open-ended questions Multiple-choice Class presentation Ability to explain lesson learned to someone else Questioning Class input Multiple choice Short answer tests	Effective strategy Involve more teachers Involve all teachers
Teacher 04	5	C	Female	7	Actively involved Tap into prior knowledge Integrating science with language arts	Paper/pencil questions Observation Engagement Explaining what was learned to someone else Using K.W.L	Hands on Insufficient science time Continuous yearly PD Need District support for science Yearly continuous PD Need District support for science Lack of funding

Teacher 05	5	C	Male	9	Experiment Lab report Questioning Tap into prior knowledge Build on their prior knowledge	Questioning Multiple choice Open-ended questions Lab report Class input Class input Writing assignments Use of rubrics	Increased content knowledge Increased pedagogical knowledge Lesson demonstrations Knowledgeable professors

Teacher 06	5/6	A	Female	7	Questioning Tap into prior knowledge Build on prior knowledge Actively involved	Paper/pencil tests Science notebook Performance in class activities Responses to teachers questions Experimentation Using pictures Ability to formulate quest Ability to investigate questions Comparing findings with what is in the book	Integration of Science/ELA Need more resources Insufficient science time Lack of literature More modeling Visit to teachers classrooms using Sc. Inquiry

Teacher 07	5	A	Female	6	Questioning Tap into prior know Cooperative learning Build on prior knowledge Clarify misconceptions Actively involved	Paper/pencil Open-ended quest Using pictures	content knowledge increase pedagogical knowledge increase Availability of lesson samples Insufficient time for sc. Visit to teachers using sc. inquiry

Teacher 08	5	D	Female	8	Questioning discussion Hands on Prior knowledge Building on prior knowledge Active participation	Lab activities Science notebooks Using pictures Student-created quiz Learner questions Observation of students' investigations Connecting what was learned Justifying explanations	Increase in content knowledge Increase in Pedagogical knowledge Exchange of ideas Share of lesson Election/appointment of teacher leaders for sustainability Conduction of workshops continuously Connect science with math and ELA so that all teachers can teach it.

Teacher 09	4	E	Male	20	Questioning Tap into prior knowledge Explanation Tap into prior knowledge	Questioning Explanation	Strength: Knowledgeable profs Use of common materials to study science Weakness: more participants needed More participants

Teacher 10	6	D	Male	6	Tap into prior knowledge Investigation Hands on Questioning Explanation	Concept understanding Questioning explanation Questioning Class input Hands on	Strengths: Knowledgeable professors Weaknesses: Lack of prof development for non-attendees Lack of support by administration Need more funding for science Replace text with hands on activities

APPENDIX K

Triangulation of Quantitative and Qualitative Data

Research question	Quantitative Results of survey questions that support inquiry	Qualitative Results
	Hypothesis 1	
Teacher Practice: How do inquiry-trained elementary teachers in one Southern California district address the five essential features of science inquiry?	•Lecture in class-100% •Require students to write us a lab report- 61% •Use questions to probe students' understandings?–100% •Learner selects among questions, poses new questions - 81.82% •Learner poses a question -90.48% •Learner sharpens or clarifies question provided by teacher, materials, or other sources – 86.36% •Learner engages in question provided by teacher, materials, or other source - 86.36%%	1.Questioning 2.Explanation
	Hypothesis 2	
	•Require students to make inferences from their observations?- 100% •Learner gives priority to evidence in responding to questions –86.36% •Learner determines what constitutes evidence and collects it - 81.82% •Learner is directed to collect certain data – 90.91% •Learner is given data and asked to analyze- 81.82% •Learner is given data and told how to analyze – 90.91%	
	Hypothesis 3	

	• Have the students engage in an investigation on a topic before formally presenting the concepts in class -77.27% • Engage students in an investigation that takes more than one class period –77.27% • Learner formulates explanations from evidence -90.91% • Learner formulates explanation after summarizing evidence – 90.91% • Learner is guided in the process of formulating explanations from evidence -86.36% • Learner is given possible ways to use evidence to formulate explanation –86.36% • Learner is provided with evidence - 95.45%	
Assessment How do inquiry-trained teachers assess student performance related to each of the five essential features of inquiry?	Hypothesis 4	1.Experiment 2.Lab
	•Require your students to make observations in class?- 81.82% •Require your students to take measurements in class?-81.82% •Require your students to collect data of some sort?- 90.91% •Require your student to manipulate experimental materials providing a hands-on experience?– 81.82% •Have your students design their own experiments or investigations?-63.64% •Engage students in investigations or lab work?–72.73% •Require your students to write up a lab report?- 61.90% •Use experiments from the text or lab manual?- 77.27% •Have the students engage in an investigation on a topic before formally presenting the concepts in class - 77.27% •Have the students engage in an investigation on a topic before formally presenting the concepts in class - 76.19% •Investigations, research reports, projects - 81.82%	
	Hypothesis 5	
	• Constructed response, essays - 81.82%	
	Hypothesis 6	
Training: What types of training experiences are	• Portfolios, journals, lab notebooks - 81. 82%	
	Hypothesis 7	Strength: 1.Effective professors 2.Availability
	• Experts modeling -95.24%	

<table>
<tr><td rowspan="4">essential to fully prepare teachers to learn and apply inquiry in their classrooms?</td><td>Hypothesis 8</td><td rowspan="4">of kits

Weakness:
3.Insufficient time for science

Recommendation
4. Involve more teachers in the program.</td></tr>
<tr><td>• Peer sharing - 95.45%</td></tr>
<tr><td>Hypothesis 9</td></tr>
<tr><td>• Focus group - 90.48%</td></tr>
</table>