FINDING SUCCESS IN ELEMENTARY SCIENCE ACROSS SOCIOECONOMIC BOUNDARIES

by

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AUTOBIOGRAPHICAL SKETCH OF AUTHOR

Jill is an Idaho native with credentials in Elementary Education, Secondary Education (biological sciences, chemistry, physical sciences, natural sciences, and standard mathematics), and K-12 Administration. Jill has Bachelor of Science degrees in *Zoology* and *Secondary Education* from the University of Idaho. Her Master's degrees in *Curriculum and Instruction* and *Educational Leadership* are from Boise State University.

Jill has 10 years of public school teaching experience in grades first through twelfth. Seven of those years were gained as the founding first through eighth grade science teacher for an Idaho charter school. While at Boise State University, she developed and taught a course titled *Investigations into Sustainable Development*, offered through the Biology, Geosciences, and Environmental Studies departments. Jill also taught courses for the education department at Boise State University, including *Elementary Science Methods*.

As a graduate advisor for the Boise State University Microgravity Research Team, she helped guide undergraduate students through the development of numerous outreach activities; the development of a NASA reduced gravity research proposal; and the fulfillment of their research agenda. She accompanied the team, composed of majors from Biology, Electrical Engineering, Mechanical Engineering, and Computer Science, to Houston where they tested their research on the *Gravitational Effects on Cerebrospinal*

Fluid Pressure and Flow in an Anatomical Model in the microgravity environment created on-board NASA’s C9 airplane.

While completing her doctorate, she had the opportunity to work as a STEM education research assistant, working on projects related to Idaho’s *iSTEM* project, *IDoTeach*, and STEM undergraduate research programs. During the last two years of her doctorate program, she worked with the Boise State University Service-Learning program as their STEM Coordinator. This role provided her the opportunity to work with professors from Chemistry, Biology, Environmental Studies, Geosciences, and Engineering, helping them to integrate service learning into their courses and assisting with the development of various STEM service-learning programs, including a teacher development opportunity called *IdahoWatch: Teacher Researcher Partnership*.

ABSTRACT

Elementary science education provides a platform for intellectual development, building a foundation of scientific literacy and a first entry point into interest in Science, Technology, Engineering, and Mathematics (STEM) fields. A significant body of research on elementary science education clearly defines what high-quality science education should look like at the elementary level. However, there is little understood about how to implement high-quality science instruction effectively within a school system. Prior research indicates that this problem is further compounded in low socioeconomic elementary schools by a lack of resources, time, and high teacher mobility. I used descriptive research to identify the presence of the key elements to elementary science reform within Idaho public schools that demonstrated consistent high science achievement. Survey responses were collected from principals and teachers from both low and high socioeconomic schools. The results of this study provide insight into how Idaho is currently defining high achievement in elementary science education and the value that Idaho schools are placing on science instruction at the elementary level. The results of this study also suggest a road map for where Idaho needs to focus efforts to achieve high-quality science achievement at the elementary level.

Keywords: elementary science education, STEM, elementary science reform, leadership in elementary science, high achievement, low socioeconomics, high socioeconomics

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LIST OF ABBREVIATIONS

AAAS	American Association for the Advancement of Science
BASEE	Bay Area Schools for Excellence in Education
BSCS	Biological Science Curriculum Study
DOK	Webb’s Depth of Knowledge
ELA	English Language Arts
ELL	English Language Learners
FRL	Free and Reduced Lunch
ISAT	Idaho Standards Achievement Test
ISDE	Idaho State Department of Education
NAEP	National Assessment for Educational Progress
NCLB	No Child Left Behind
NCES	National Center for Educational Statistics
NGSS	Next Generation Science Standards
NRC	National Research Council
NSTA	National Science Teachers Association
SES	Socioeconomic Status
STEM	Science, Technology, Engineering, and Mathematics
USP	Urban System Project

CHAPTER ONE: INTRODUCTION

Introduction

Elementary science education provides a platform for intellectual development, building a foundation of scientific literacy and an entry point into interest in Science, Technology, Engineering, and Mathematics (STEM) fields (Allen, 2006; American Association for the Advancement of Science [AAAS], 1993b, 2009; Furtado, 2010; Keeves, 1995; Michaels, Shouse, & Schweingruber, 2008; National Research Council [NRC], 2007). There has been significant research conducted on high-quality science education and there is little debate about what high-quality instruction should look like at the elementary level (Allen, 2006; Anderson, 2002; Bennett, Lubben, & Hogarth, 2006; Dorph, Shields, Tiffany-Morales, Harty, & McCaffrey, 2011; Michaels et al., 2008; Minner, Levy, & Century, 2010; NRC, 2007; Shymansky, Hedges, & Woodworth, 1990). Inverness Research Associates (2007) defined four key elements needed to achieve elementary science reform. These key elements include: Programs and Practices; Assessment and Feedback; Instructional Leadership and Mandate; and Professional Development. Despite this knowledge, it is well documented that few elementary schools provide consistent high-quality instruction in elementary science (Anselm & Moore, 2007; Dorph et al., 2011; Enochs & Riggs, 1990; Riggs & Enochs, 1990; Spillane, Diamond, Walker, Halverson, & Jita, 2001; Stake & Easley, 1978; Weiss, 1978). This problem is further compounded in low-socioeconomic elementary schools by a lack of resources, time, and high teacher mobility (Banilower, Smith, Weiss, Malzahn, Campbell, & Weis, 2013; Berryman, 1983; Dorph et al., 2011; Lynch, Kuipers, Pyke, & Szesze, 2005).

Background

The National Assessment for Educational Progress (NAEP) continues to report a significant gap, nationally, in science education between low and high-socioeconomic students (National Center for Educational Statistics [NCES], 1992, 1997, 2011). Idaho's NAEP results mirror this trend (NCES, 2011). Despite these findings, some schools are able to overcome the challenges associated with low socioeconomics and achieve at high levels in all curricular areas, including science (Haycock, 1998; Idaho State Department of Education [ISDE], 2011a, 2012a, 2013a; Kane & Cantrell, 2009; Konstantopoulos & Borman, 2011).

Research examining how low-socioeconomic schools are able to achieve and out-perform their high-socioeconomic counterparts is limited, possibly a result of the need to first question the Coleman study (Coleman et al., 1966). Coleman et al. (1966) identified socioeconomic status (SES) as a predictor of academic achievement and social effectiveness. The Coleman report was authorized under the 1964 Civil Rights act and was the second largest social science research project in history, with 600,000 students and 4,000 schools participating nationally. Coleman et al. (1966) reported,

> School brings little influence to bear on a child's achievement that is independent of his background and general social context; and that this very lack of an independent effect means that the inequalities imposed on children by their home, neighborhood, and peer environment are carried along to become the inequities with which they confront adult life at the end of school. (p. 325)

Reform models attempting to refute the findings of Coleman et al. (1966) are not widespread in Idaho (Parrett & Budge, 2012). Without a clear predictor of why some schools across the state are achieving so highly, under difficult circumstances, it is important to evaluate both the school and classroom-level influences on elementary science success.

Influences on Elementary Science Achievement

Elementary science program effectiveness can be influenced at multiple levels. These levels of influence include: the school level, the classroom level, and the external environment. The external environment includes everything outside of the school, such as the political environment, parental-education level, parental support, socioeconomic status, and outside experiences. Schools can have little influence on the external environment. This study evaluates the influences at the school and classroom level on high achievement in elementary science, within the external environment of low and high socioeconomics.

High achievement is defined many ways throughout the literature. For the purposes of this study, high-achieving schools in science had to meet the following criteria: (1) Maintain consistent performance over the past three years on the fifth grade science Idaho Standards Achievement Test (ISAT); (2) Achieve ISAT school-level scale scores within advanced (216+) or in the top third of proficient (215-212) on the fifth grade science ISAT; and (3) Have at least 30% of fifth graders performing within advanced (216+) on the science ISAT (ISDE, 2007b, 2011a, 2012a, 2013a).

Socioeconomic status (SES) is defined as the hierarchical ranking of individuals or families based on access to jobs, wealth, assets, power, and social status (Mueller &

Parcel, 1981). The method of measuring SES varies widely across educational research. One common method of measuring SES comes from the use of Free and Reduced Lunch (FRL) status. For the purpose of this study, I have chosen to use FRL status to identify low-SES schools. The Title One qualifier for whole-school intervention in Idaho is school-level FRL qualifications of 40% or greater. I have defined schools meeting this criterion as low SES. Free and Reduced Lunch qualification of 25% or less at the school level was defined as high SES.

The Classroom Level

Research on the classroom level has dominated elementary science education research since the 1960s. Research on elementary science education at the classroom level has included: cognitive development through elementary science instruction (Adey, 2004, 2008; Adey, Robertson, & Venville, 2002; Adey & Shayer, 1993, 1994; Endler & Bond, 2001, 2008; Hu et al., 2011; Karplus & Thier, 1969; Shayer, 1996; Shayer & Adey, 1981, 1993, 2002), instructional methods (Bredderman, 1974, 1983, 1985; Dickerson, Clark, Dawkins, & Horne, 2006; Furtak, Seidel, Iverson, & Briggs, 2012; Karplus, 1962, 1964, 1977; Karplus & Thier, 1969; Klentschy, 2002; Klentschy, Garrison, & Amaral, 2001; Shymansky, Kyle, & Alport, 1983; Vanosdall, Klentschy, Hedges, & Weisbaum, 2007), science instruction with English language learners (Dickerson et al., 2006; Klentschy, 2002; Klentschy et al., 2001; Vanosdall et al., 2007), science instruction with children who have mental and physical impairments (van Benthem, Dijkgraaf, & de Lange, 2008), teacher efficacy (Joseph, 2010; Riggs & Enochs, 1990), and teacher content knowledge (Alonzo, 2002; Brickhouse, 1990; Heller, Daehler, & Shinohara, 2003; Lederman, 1999; Nehm & Schonfeld, 2007). Despite an understanding of why elementary science is important and an understanding of what high-quality instruction includes, there has been little system-wide change in elementary science instruction over the last fifty years.

The School Level

Lack of change, despite overwhelming evidence in favor of inquiry-base elementary science instruction, has prompted research to take a different direction, looking for other influences on change at the classroom level. More recently, research has looked toward school leadership and external resources to understand how they influence student achievement in elementary science. Research on the principal's influence on elementary science instruction is still new and only a handful of studies have been conducted. Research on the school level includes work by Spillane et al. (2001) who conducted a qualitative study on schools in poverty (60% Free and Reduced Lunch qualification or higher) in the process of educational reform. Spillane et al. (2001), looked at distributed leadership, focusing on human resources, social capital, and physical resources. They found that not all elementary schools achieved success in the same manner, and that some schools that had resources, both social and capital, were ineffective in reform because they were unable to activate their resources. Spillane et al. (2001) also found strong evidence that support from positional leaders is crucial in activating and sustaining school-wide reform. Research by Lanier (2008) and Casey, Dunlap, Brown, & Davison (2012) found that in order for elementary science programs to match the message of reform, principals as instructional leaders are integral. Based on the work by Casey et al. (2012), Lanier (2008), and Spillane et al. (2001), it is apparent that the effect of leadership within the school cannot be discounted when looking for influences driving low-SES school achievement.

Identifying a Gap in Understanding

Outside of national and state-level reports, there has been no comprehensive research conducted, to date, that has looked collectively at driving influences of school and classroom-level influences in high science achieving disadvantaged elementary schools (Banilower et al., 2013; Dorph et al., 2011). A knowledge gap exists in our understanding of what influences similarly achieving schools from high and low-SES demographics to achieve highly in science, leaving ten percent of Idaho elementary schools performing below proficient in elementary school science (ISDE, 2012a).

Problem Statement

Outside of report data, comprehensive research to provide a collective evaluation of school and classroom-level influences driving high science achievement in disadvantaged elementary schools is lacking (Banilower et al., 2013; Dorph et al., 2011). This knowledge gap also persists in our understanding of what influences in similarly achieving schools from high and low-SES demographics move students to high achievement. Without an understanding of the interplay between school and classroom-level influences driving high achievement in elementary science, our education system has become paralyzed in the implementation of high-quality elementary science instructional system wide. These gaps in our understanding of how to successfully implement high-quality elementary science instruction have resulted in high numbers of schools opting out of science instruction and low levels of performance in elementary school science (Anselm & Moore, 2007; Banilower et al., 2013; Berryman, 1983; Dorph et al., 2011; Enochs & Riggs, 1990; Lynch et al., 2005; Riggs & Enochs, 1990; Spillane et al., 2001; Stake & Easley, 1978; Weiss, 1978).

Purpose of Study

The purpose of this study is to identify if the implementation level for each of the four key elements needed to achieve elementary science reform, as described by Inverness Research Associates (2007), are present in high science achieving elementary schools in the state of Idaho. This study also sets out to identify how the implementation level for each of the key elements differ between low and high-socioeconomic Idaho elementary schools that are achieving highly in science.

The implementation level for each of the key elements of reform (programs and practices; assessment and feedback; instructional leadership and mandate; and professional development) was evaluated at the school and classroom level (Inverness Research Associates, 2007). I used the perspective of the principal to evaluate the school level and the perspective of elementary teachers to evaluate the classroom level, using Internet-based survey tools.

Research Questions and Hypotheses

This study sets out to answer the following questions and sub-questions:

Question 1: In Idaho, are all of the four key elements present in all of the high science achieving elementary schools? This question was further broken into four sub-questions:

- Is there evidence of the element Programs and Practices found within all of the high science achieving elementary schools in Idaho?

- Is there evidence of the element Teacher Background and Development found within all of the high science achieving elementary schools in Idaho?
- Is there evidence of the element Instructional Leadership and Mandate found within all of the high science achieving elementary schools in Idaho?
- Is there evidence of the element Assessment and Feedback found within all of the high science achieving elementary schools in Idaho?

Hypothesis 1: Based on three years of science ISAT results, the identified Idaho schools have consistently developed high achievers in science (ISDE, 2011a, 2012a, 2013a). As a state, Idaho has scored above the national average on the last National Assessment of Educational Progress (NAEP) test given in the elementary grades (NCES, 2011). The NAEP test is a rigorous test that tests beyond rote knowledge, making it reasonable to believe that evidence will be present in all of the highest science achieving schools in the state indicating that they are engaged in delivering all four key elements considered important to achieving success in elementary science.

Question 2: In Idaho, high science achievement can be found in both low and high socioeconomic status elementary schools. Does the evidence indicate a difference between the low and high-SES schools' implementation of the key elements to elementary science reform in Idaho high science achieving schools? This question was further broken into four sub-questions:

- Is there a difference in the implementation of Programs and Practices between Idaho low and high-SES, high science achieving elementary schools?

- Is there a difference in the implementation of Teacher Background and Development between Idaho low and high-SES, high science achieving elementary schools?
- Is there a difference in the implementation of Leadership and Mandate between Idaho low and high-SES, high science achieving elementary schools?
- Is there a difference in the implementation of Assessment and Feedback between Idaho low and high-SES, high science achieving elementary schools?

Hypothesis 2: Based on the different pressures created by socioeconomic status in low and high-SES schools, the ability to implement each of the key elements will be different in the high science achieving, high and low-SES schools.

Theoretical Basis

The theoretical basis of this proposal was framed around the key elements of elementary science reform (Inverness Research Associates, 2007), then evaluated at the school and classroom level. At the classroom level, quality science instruction was theoretically framed by constructivist learning theory. While at the school level, the study was framed around instructional leadership theory.

Theoretical Basis for the Key Elements to Elementary Science Reform

The key elements to elementary science—(1) Program and Practice; (2) Teacher Background and Development; (3) Instructional Leadership and Mandate; and (4) Assessment and Feedback—were established from over 25 years of research and evaluation of elementary science reform efforts by Inverness Research Associates (2007). Inverness Research Associates (2007) gathered their multitude of multi-faceted data from participant observations, in-depth interviews, focus groups, surveys, and document review research and evaluations of National Science Foundation (NSF) funded State Systemic Initiative projects, five Local Systemic Change Projects, a rural systemic initiative, and four urban systemic initiatives. In Chapter Two, I will review three of these elementary science projects. Each is large in scale, National Science Foundation funded, and focuses on implementing high-quality elementary science instruction into districts where quality and quantity of elementary science instruction was lacking.

Classroom Level Theoretical Framework

Research over the past 50 years has shown that high-quality elementary science instruction is achieved through the implementation of methods that are supported by the constructivist learning theory. These methods will be discussed in Chapter Two, but the essential elements are based on the belief that learning occurs as learners are actively involved in the processes of meaning and knowledge construction, as opposed to passively receiving information (Driscoll, 2005). If implemented properly, instruction based on constructivist learning theory should focus on fostering critical thinking and creating motivated, independent learners. This theoretical framework maintains that learning builds upon knowledge that a student already holds. This prior knowledge is referred to as schema by Piaget (Driscoll, 2005). As students encounter conflicting experiences, they must restructure their knowledge, something that Piaget refers to as schema accommodation (Driscoll, 2005). During instruction based on constructivist learning theory, the role of the teacher is to model, coach, and scaffold learning, emphasizing learning in context, with defined thinking activities as central. Problem-based learning and inquiry-based learning are both models of teaching that are based on constructivist learning theory, both of which represent the core elements of what has been identified as quality science instruction.

School Level Theoretical Framework

Instructional leadership theory is based on the belief that instructional quality is one of the most important factors in effective teaching. Without quality instruction, school reform is not possible. Instructional leadership includes all actions that a principal performs or delegates for the purpose of promoting growth in student learning (DeBevoise, 1984). By making instructional quality the top priority, the principal encourages educational achievement and makes that vision a reality. As an instructional leader, principals work with teachers to define educational objectives, set school wide goals, provide the necessary resources for learning, create new learning opportunities for students and staff, and provide effective feedback that is consistent with and helps to shape quality instruction in their teachers (Wildy & Dimmock, 1993). Instructional leadership theory holds that the leader is a key element to instructional reform. Glickman (1990) found that instructionally effective schools have principals who have become the primary instructional leader in their school, and the presence of an organizational phenomenon of collective action, an agreed-on purpose, where teachers perceive that they are part of something that is beyond them. Bamburg and Andrews (1990) described effective instructional leaders as the following: a resource provider that is knowledgeable about curriculum and instruction; an instructional leader that sets expectations for continual improvement of instructional program and actively engages in staff development as well as encourages the use of different instructional strategies; an effective communicator that models commitment to school goals and articulates a vision of instructional goals and a means for attaining these goals; provides a visible presence in classrooms, collaborative meetings, and is accessible. Each of these factors is key in developing principals who are able to become key participants in helping students achieve.

Nature of the Study

This descriptive study was designed to identify if the key elements, identified as necessary to achieve elementary science reform, were present within science achieving elementary schools in the state of Idaho. This study also set out to identify if the implementation level for each of the key elements to elementary science reform differed between low and high-socioeconomic science achieving elementary in Idaho.

The study made use of descriptive analysis and between-measures analysis to answer the two overarching questions. Descriptive analysis was used to identify if the key elements were identifiable within the high science achieving elementary schools in the state of Idaho. Between-measures analysis was used to reveal the implementation level for each of the key elements to elementary science reform between high science achieving, low and high-SES elementary schools in Idaho.

The independent variable for the between-measures analyses was socioeconomic (SES) status, as determined by school-level Free and Reduced Lunch (FRL) qualification. This variable was broken down into high SES (25% or less qualification for FRL) and low SES (40% or higher qualification for FRL). The independent variables for the normative analyses are Idaho high science achieving school participants and national school participants.

The dependent variables in the study were the four key elements to elementary science reform. These variables were measured through the perspective of the elementary school principal and teachers using an adaptation of 2012 National Survey of Science and Mathematics Education: Science Program Questionnaire (Horizon Research, 2012b) and an adaptation of the 2012 National Survey of Science and Mathematics - Science Teacher Questionnaire constructed by Horizon Research (2012c). Each of the tools used in this study were aligned to the key elements elementary science reform: Programs and Practices, Assessment and Feedback, Instructional Leadership and Mandate, and Teacher Background and Development (Inverness Research Associates, 2007)

The measurable dependent variables included nominal, interval, and ratio survey and protocol responses, as well as short answer responses that were analyzed using qualitative coding methods. Purposive sampling was used to select the participating high and low-SES participant schools. High-SES schools were compared to low-SES schools, scoring within the same scale score bands on science, math, reading, and language on the fifth grade ISAT. By looking at schools with similar scores, I minimized reading, language, and mathematics as confounding variables.

Assumptions, Limitations, Scope, and Delimitations

There were three key assumptions in this study. These assumptions include: 1.) The data collection and data analysis methods were accurate and capable of answering the proposed research questions; 2.) The participants in the study provided true, accurate, and thoughtful answers to the self-report survey questions; and 3.) The science ISAT is an accurate measure of high-quality science achievement.

Limitations included lack of generalizability of the ISAT science scale scores outside of the state of Idaho. Each state has independently developed its own state-level science assessment, creating an inability to compare test scores across states. The NAEP science test is the only widely used, nationally given, science test at the elementary level. Scores on the NAEP test are not broken down below the state level. As a result, the NAEP science test does not provide comparable test scores at the school level, leaving only state developed tests, such as the ISAT to evaluate the effectiveness of elementary science education.

In an effort to remove the potentially compounding variables of mathematics, language arts, and reading abilities, I only looked at similarly achieving schools. The high science achieving schools were also high performers in mathematics, language arts, and reading. It is not possible to know how much high achievement in other content areas influenced achievement on the science ISAT. However, there were Idaho schools that were high achieving in language arts, mathematics, and reading that were not high achieving in science, indicating that high science achievement is not solely a measure of high achievement in language arts, mathematics, and reading.

Since a “model” of elementary science does not currently exist, I was limited to using key elements to elementary science reform, defended in the literature, to scaffold the study (Inverness Research Associates, 2007). Instruments used to survey participants about science education, assessment, and leadership were limited and did not contain Cronbach alpha reliability coefficients associated with them. However, the composites of questions I was able to use with Cronbach’s alpha reliability coefficients previously demonstrated strong to moderate reliability, and maintained this level of reliability on this survey.

I followed contact protocols to minimize potential bias in the study. I know one of the principals of the schools I asked to participate in the study and I previously worked for one of the schools that I asked to participate in the study. I followed procedures to reduce the possibility of bias, despite my personal associations with various principals, teachers, and schools in Idaho. ISAT data sets are reported using school codes, so I was unaware of schools' names during the original selection process. Once I identified schools that met the criteria for participation, I became aware of each school's name. I followed contact protocols, even with individuals that I knew, and I did not discuss the study with any of them until after their districts provided consent for me to work in their district.

Significance of the Study

Very little research has been conducted to examine how, within a culture of low socioeconomics, some schools are able to achieve and out-perform their high socioeconomic counterparts. The National Assessment for Educational Progress (NAEP) has reported a significant gap, nationally, in science education between low and high socioeconomic students (NCES, 1992, 1997, 2011). Idaho's NAEP results mirror this trend (NCES, 2011). Outside of national and state-level reports, there has been no comprehensive research conducted, to date, that has looked collectively at driving influences of school and classroom-level influences in high science achieving disadvantaged elementary schools (Banilower et al., 2013; Dorph et al., 2011). A knowledge gap persists in our understanding of how similarly achieving schools from high and low-SES demographics move students to high achievement. These gaps in our understanding of what drives elementary science achievement has left 10% of Idaho elementary schools performing below proficient in elementary school science (ISDE, 2012a). Understanding what influences, in Idaho, enable schools of diverse socioeconomic backgrounds to achieve is critical in helping Idaho schools who are low performing in elementary science.

Definition of Key Terms

There are terms used regularly throughout this document that may not have a common universally understood definition; I have defined each of these terms for the purposes of this study.

Assessment and Feedback – Assessments are a method of establishing evidence of students' ability to use scientific practices, apply their understanding of crosscutting concepts, and draw on their understanding of specific disciplinary ideas, over time (Pellegrino, Wilson, Koenig, & Beatty, 2014). Student assessment should come from a variety of approaches, including: diagnostic, formative, summative, and performance. Data collected from these assessments provides continuous feedback on a teachers' instructional effectiveness, their students' learning, and should be used to make data-driven decisions about refinement of curriculum and instructional practices (Inverness Research Associates, 2007; Pellegrino et al., 2014).

Classroom Level – The level at which the teacher has influence on student achievement.

Elementary School – Any school containing the fifth grade; for example, this may include Grades K–5, K–6, K–8, 3–5, 4–5.

High Achieving Elementary Science School – Elementary schools that: (1) Maintain consistent performance over a three year span on the fifth grade science ISAT; (2) Achieve ISAT school-level scale scores within advanced (216+) or in the top third of proficient (215-212) on the fifth grade science ISAT; and (3) Have at least 30% of fifth graders performing within advanced (216+) on the science ISAT (ISDE, 2007b, 2011a, 2012a, 2013a).

High-Quality Elementary Science Instruction – Instruction that links content and process skills, through the use of inquiry instruction. This instruction should focus on crosscutting principles and should develop students' understanding of scientific explanations, generate scientific evidence, cause students to reflect on scientific knowledge, and encourage active participation in science (Michaels et al., 2008).

High Socioeconomic Status (SES) – Schools with less than 25% of their students that qualify for FRL.

Instructional Leadership and Mandate – Instructional leadership encompasses all actions performed or delegated by a leader for the purpose of supporting teachers' development and promoting student growth in science. This instructional leadership in science should extend from positional leaders to shared leadership roles within the school (DeBevoise, 1984; Spillane et al., 2001; Inverness Research Associates, 2006b, 2007; Casey et al., 2012). Instructional mandate is the requirement of a school and its teachers to implement science instruction, encompassing the quality of instruction and the quantity of instruction (Inverness Research Associates, 2006b, 2007; St. John, Heenan, Heenan, & Helms, 2007)

Low Socioeconomic Status (SES) – Schools with 40% or more of their students that qualify for FRL, defined using the Title One qualifier for whole-school intervention, which is 40% FRL at the school level.

External Environment – The level at which influences on student achievement are outside the control of the school, examples include: policy, parental education, and experiences occurring outside of school.

Program and Practice – Program and Practice encompasses both the quality and quantity of the adopted instructional program and instructional practice within a school. A quality program is identifiable by the adoption, implementation, and support of high-quality instructional materials and instructional practices that meet state and district standards, and are consistent with the higher-order vision of the National Science Standards or the Next Generation Science Standards. The quantity of a program is identifiable by the number of hours dedicated to weekly instruction of science (Inverness Research Associates, 2006b, 2007; St. John et al., 2007).

School Level – The level at which the school building administration or individuals acting in a leadership role within the school building have an influence on student achievement.

Socioeconomic Status (SES) – A hierarchical ranking of individuals or families based on access to jobs, wealth, assets, power, and social status (Mueller & Parcel, 1981), as defined at the school level by the percentage of students qualifying for Free and Reduced Lunch (FRL) status.

Teacher Background and Development – Teacher background encompasses a teacher’s years of experience as an educator, and a teacher’s formal education in teaching pedagogy and science content. Teacher development comes from the access to professional development (PD) that focuses on both pedagogy and content. The highest quality PD comes from sustained professional development (50+ hours) that promotes collaborative approaches, builds strong relationships among teachers, connects to classroom practice, and focuses on teaching and learning specific academic content (Heenan & Helms, 2013).

Summary

Despite the many studies conducted over the last 50 years on elementary science instructional methods, there still exists a lack of understanding of how to implement quality science instruction across an entire school or throughout school systems. Issues that instigated instructional reform in the 1960s are still the issues of today. It is important to look at a broader range of stakeholders. This study focused on stakeholders that had direct influence over student achievement: the principals and teachers. By collectively evaluating the implementation level for each of the key elements to elementary science reform at the school level and classroom level, in high achieving elementary science programs across the state of Idaho, this study sought to identify commonalities and differences between participant low and high-SES elementary schools in Idaho (Banilower et al., 2013).

CHAPTER TWO: REVIEW OF RELATED LITERATURE

Introduction

With the shift, nationally, in the economic base towards technology, increased concerns have surfaced that the United States may not be able to meet future scientific and technological needs without a substantial increase in students entering Science, Technology, Engineering, and Mathematical (STEM) fields (NRC, 2005; Oakes, Ormseth, Bell, & Camp, 1990). This needed increase in a scientific literate society may be achieved through increasing the number of students developing an interest in STEM fields during early exposure in the elementary grades and by increasing the number of underrepresented groups entering STEM fields (Oakes et al., 1990; Tai, Liu, Maltese, & Fan, 2006). In this literature review, I will identify the importance of early exposure to science education. I will provide a thorough discussion of the theoretical framework of high-quality elementary science education. I will establish the importance of strong instructional leadership for achieving elementary science reform, and the theoretical framework for instructional leadership. I will then establish the existence of the achievement gap between low and high socioeconomic status students in elementary science achievement. I will provide an explanation of elementary science achievement measures and introduce the key elements of elementary science reform as a framework for evaluating the presence of support for high-quality science education in Idaho high science achieving elementary schools.

The purpose of this study was to identify the presence of each key element in the identified Idaho high science achieving schools and to identify the differences in the presence of these elements between low and high socioeconomic Idaho schools.

Importance of Early Exposure to Science Education

Children begin school with a rich knowledge of the natural world, innate curiosity, the ability to demonstrate early reasoning, and an interest in the discovery of new knowledge (NRC, 2007). The implementation of high-quality elementary science programs further develop and nurture these early tendencies into higher-order thinking skills and problem-solving skills. These skills include: the ability and propensity to ask questions, observe closely, evaluate, analyze, look for evidence, and think rationally.

The goal of high-quality elementary science instruction is to develop a student's power to reason and solve problems in a scientific way. Thus, teachers must feel comfortable with guiding student-driven investigations and discussions in the early grades (Elstgeest & Harlen, 1985). Research indicates that teachers find helping students to develop scientific thinking, understand scientific methodology, and develop student-driven investigations their greatest challenge (Aschbacher & Roth, 2002). Even in schools where professional development (PD) is provided, observations reveal low cognitive demand placed on the students. This low cognitive demand comes from the teachers failing to provide students with opportunities to respond to questions and not requiring students to provide evidence or explanations for their thinking, resulting in low cognitive demand (Aschbacher & Roth, 2002). Additional research indicates that science is not being taught in many elementary grades with high priority or in a way that is consistent with what is considered high-quality instruction (Anselm & Moore, 2007;

Dorph et al., 2011; Enochs & Riggs, 1990; Riggs & Enochs, 1990; Spillane et al., 2001; Stake & Easley, 1978; Weiss, 1978).

The lack of high-quality science instruction at the elementary level is problematic, since elementary students need access to good science instruction as early as possible (Mulholland & Wallace, 2005). Exposure to high-quality scientific content and processes in the elementary grades is crucial to building a strong foundation for further scientific learning and intellectual development of arguments (Allen, 2006; AAAS, 1993b; Furtado, 2010; Keeves, 1995; Michaels et al., 2008; NRC, 2007; Rowe, 1992). The development of these skills is the focus of a high-quality science education.

Theoretical Framework

The theoretical basis of this proposal was framed around the key elements to elementary science reform, and evaluated at the classroom level and at the school level. At the classroom level, I framed quality science instruction around constructivist learning theory. While, at the school level, I framed the study around instructional leadership theory.

Theoretical Basis for the Key Elements to Elementary Science Reform

Using more than twenty-five years experience as a nationally recognized independent project evaluator for many successfully established and sustained high-quality science programs, derived from multiple National Science Foundation State Systemic Initiative projects, five Local Systemic Change Projects, a rural systemic initiative, and four urban systemic initiatives, St. John, founder of Inverness Research Associates, unveiled the key elements to elementary science education reform during a congressional briefing in 2007 (Inverness Research Associates, 2007). St. John stated the following:

> There is no secret about what it takes to install a strong elementary science program. A good well-rounded curriculum that is supported by well-designed instructional materials as the centerpiece. These materials, in turn, need to be supported by district or regional science materials center that assures teachers will have the materials they need to teach science.
>
> A wide range of professional supports is also key so that teachers have the opportunity to learn how to teach their science kits, develop deeper understandings of content, become experts in facilitating student inquiries, learn how to use science journals, and become better at assessing their students' learning. Teachers also need good assessments and other ways to get feedback on their teaching. Finally, teachers need to be supported by strong science leaders and also administrators who can help them improve their practice and make the case for science in their districts. The administrative leaders in the district need to make science a priority and establish a clear mandate for its teaching.
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> With these elements in place, high-quality elementary science instruction becomes a high, rather than a low, probability event. (Inverness Research Associates, 2007, p. 25)

The key elements to elementary science reform are: (1) Program and Practice; (2) Teacher Background and Development; (3) Instructional Leadership and Mandate; and (4) Assessment and Feedback. St. John et al. (2007) identified these elements as key supports necessary for elementary science reform changes, after seeing that these elements were present in each of the schools that they had identified as having developed a successful, sustained, elementary science reform projects that provided high-quality science education for their students. The research design used by Inverness Research Associates to evaluate improvement projects in science education, which ultimately allowed them to identify the key elements to elementary science reform, included a multi-faceted approach that gathered data from participant observations, in-depth interviews, focus groups, surveys, and document reviews. There are many studies that have been conducted by Inverness Research Associates that document the presence of each of key elements in school districts that successfully implemented elementary science reform. I will discuss three of these projects. Each of the projects that I discuss was large in scale, National Science Foundation (NSF) funded, and focused on implementing high-quality elementary science instruction in districts where quality and quantity of elementary science instruction was lacking. These projects include: a six year study of the Gilbert School District, Arizona; the San Diego Urban System Project, California; and finally, a fifteen year legacy study of the Bay Area School District, California.

The Gilbert Systematic Science Plan

The Gilbert Systemic Science Plan began as a NSF funded project in 1999 to implement an elementary science program across the Gilbert Public School District capable of serving all of the district's young students (Inverness Research Associates, 2006b). Inverness Research Associates (2006b) evaluated the project during its sixth year. The presence of each of the key elements in the Gilbert Systemic Science Plan was documented. In regards to Programs and Practice, Gilbert Public Schools piloted, selected, and adopted into use three to four NSF funded and nationally recognized kits from Full Option Science Systems (FOSS) or Science and Technology for Children (STC). Gilbert put in place a central kit refurbishment center within their district to manage the cleaning and replenishment of each of the 1,895 kits district-wide for their 25 elementary schools. During the first year of implementation, the Inverness research team observed in ten classrooms and found that only five of these classrooms were implementing NSF funded instructional materials, none of science lessons incorporated a science notebook, and only 30% of lessons were judged to be of high quality. By the spring of 2005, the Inverness research team observed 18 teachers. All of them were using NSF funded instructional materials, and 89% of the lessons incorporated science notebooks and were judged to be of high quality. Gilbert Public Schools addressed Teacher Background and Development by providing annual workshops to the district's 1,555 teachers for the purpose of developing effective use of the FOSS and STC kits, increasing effective use of science notebooks, and increasing teachers' content knowledge within areas addressed by the kits. Teacher professional development was tiered to provide opportunities for all teachers to expand their knowledge and pedagogy of science content and science skills. Workshops were also held to develop and train one to two teacher leaders from each school to implement teacher training workshops and increase the teacher leaders' background in targeted areas through field experiences with specialists and scientists. There were as many as 109 workshops held during one school year to service 1,555 teachers. Instructional leadership came primarily from a district science team composed of an elementary science coordinator, two science resource teachers, the science material center staff, one to two lead teachers from each elementary school, and a professional consultant from a neighboring district. Elementary principals and district administration provided support for the process, but the process was lead by the district science team. The science coordinator developed deeper buy in by the principals by taking key principals with her to national science conferences. She also showed them how Gilbert Public Schools was part of a largely national movement to change science teaching and learning at the elementary school level. Teachers were required to participate in kit training prior to checking out their first science kit. The science team provided principals with data regarding the number of hours each teacher logged in to science professional development. The data was then used to help target each school's needs. Assessment and Feedback of student learning came from state-mandated assessments in science, student notebooks that were used for various forms of assessment, including formative and summative, and FOSS unit assessments. Notebooks were also used as a method of providing students with feedback (Inverness Research Associates, 2006b).

San Diego Urban System Project (San Diego USP)

The San Diego Urban System Project, CA (St. John et al., 2007) was a K-12 initiative aimed at improving teaching and learning in math and science. The initiative was funded by NSF over five consecutive years, affecting 133,000 students, who spoke 60 different languages and dialects, and approximately 4,500 teachers. Program and Practice was addressed by the adoption of FOSS kits in the elementary grades. In addition, the district worked with the inquiry-based curriculum development group, Biological Sciences Curriculum Study (BSCS), to build capacity and implement new instructional materials. Teacher Background and Development was met through the development of large-scale and high-quality professional development for teachers. They built infrastructure for professional development that responded to teachers' increased sophistication, offering an ever-evolving set of challenges for administrators, teachers, and students that were cumulative, strategic, and right for the system. Over the course of one school year, K-12 teachers participated in professional development focused on science. Classroom teachers spent 6 hours while coaches and lead teachers spent up to 80 hours in professional development. Instructional leadership and mandate were taken very seriously within these and previous initiatives. Under the Blueprint for Student Success initiative for literacy and mathematics, principals were expected to act as instructional leaders, providing intensive professional development to their teachers and spending about two hours each day in classrooms. Under the San Diego USP, leadership teams of principals, vice-principals, and teachers received training on identifying high-quality science pedagogy and developing science content. Two teacher leaders were established within each elementary school, one for coordinating materials and another for leading peers in lesson study. Content administrators were established that worked collaboratively with teachers and principals. The leadership team designed and delivered workshops, provided teacher coaching, identified and chose curriculum, and designed assessments. The district took the development of strong, well-defined district wide math and science programs, at every level, and for all students, very seriously. They mandated the use of adopted instructional materials district wide and required participation in the accompanied professional development and assessment supports. Their mandates were deliberately engineered mechanisms to ensure that all students were exposed to the same curriculum, leveling the playing field for all students. Assessment and Feedback was achieved through assessments aligned to the units teachers taught, use of science notebooks, and monitoring of state and district-mandated testing (St. John et al, 2007).

Bay Area Schools for Excellence in Education (BASEE)

Bay Area Schools for Excellence in Education (BASEE), San Francisco, CA was a five year (Inverness Research Associates, 2011; Heenan & Helms, 2013) NSF funded project involving eight school districts. It initially began as an investment from Hewlett-Packard Corporation to implement a kit-based hands-on elementary science program, including training at the National Science Resources Center in Washington, DC. Looking at Program and Practice, the BASEE initiative continued the support for FOSS kits within the district and support for the district refurbishment center. Inverness Research Associates did a legacy study 15 years after the implementation of the BASEE initiative. They found that the use of FOSS kits was still institutionalized within district elementary schools and that despite the presence of the financially strapped district, a method of refurbishment of these kits still existed. Teacher Background and Development created by the BASEE initiative, and other initiatives that occurred before and after BASEE, provided extensive teacher and administrator training in elementary science pedagogy and content knowledge. BASEE specifically provided four strands of professional development, which introduced teachers to the kits, development of content background, provided teacher leadership development, and provided training for administrators in supervision of science teaching. The legacy study found that many of the teachers that were trained by BASEE were still teaching and that a pool of teacher leaders still advocated for elementary science education. Inverness Research Associates found that the training BASEE provided was deeply ingrained in the teachers who had participated in the trainings. Some of these ingrained trainings were seen in the commitment to still use the FOSS instructional materials, engage students in inquiry-based science instruction, and work with other teachers. During the legacy study, Inverness Research Associates found that the administrative support for science education, although not what it was during the implementation of BASEE, still existed within the district. During implementation of BASEE, principals were trained in supervision of science instruction, teachers were trained as leaders, science coaching occurred, and lesson study groups existed. Some of these formal leadership roles no longer existed, but building and district support for science instruction was still supportive. One weakness of the Inverness Research Associate's legacy report was that Assessment and Feedback was not discussed, despite its presence in the BASEE project. Hennan and Helms's (2013) BASEE legacy study shows us,

> … longer term sustained funding for science education improvement is important in developing champions with expertise and commitment, human capital necessary for achieving sufficient strength and durability to weather lean and unpropitious times. Funding is most effective when focused on creating supportive environments for local educational improvement efforts, aiming funding toward creating the capacity for ongoing improvements in instruction, through the development of teacher leaders and networks. (p. 3)

The insight that the sustained work of Inverness Research Associates has contributed over longer periods of time and multitudes of districts across the United States provides us a rare glimpse into the mechanical workings of districts before, during, and after change occurs. Their work has contributed to the theoretical basis for what is necessary to create change in science instruction within the elementary school environment (Inverness Research Associates, 2011; Heenan & Helms, 2013).

High-Quality Elementary Science, the Classroom Level Theoretical Framework

During the 1960s and 70s a huge outgrowth of research and understanding of thinking and learning in science education occurred as a result of low achievement in math and science and entry into the Sputnik era (Karplus & Thier, 1969; Shayer & Adey, 2002). Surprisingly, many of the views that were held in the 1960s about science education are still held today. Karplus (1962) has been noted as saying,

> Teachers' colleges require [too] few science courses for graduation; many [elementary] teachers feel inadequately prepared to teach science; many school districts allot less than an hour a week to science instruction; and … science competes for [teaching] time with reading, writing, and arithmetic. (p. 243)

The result of science reform of the 1960s-70s was the development of several new elementary science education programs that focused on the interactions between cognitive development and the development of scientific thinking and reasoning (Karplus & Thier, 1969). The result of this research in the United States (US) was the development of Science Reasoning Patterns and the Learning Cycle (Karplus & Thier, 1969). This movement in the US was mirrored in the United Kingdom (UK) by their concern with poor math and science achievement at the secondary level. Similarly, this reform movement in the UK resulted in investigations into cognitive development and the development of scientific thinking and reasoning (Shayer & Adey, 2002). The result of the research in the UK was a process known as Cognitive Acceleration and the 5-pillar approach to science instruction. This research contributed greatly to our understanding of what high-quality science instruction encompasses, and the development of the term inquiry instruction.

Inquiry instruction is developed from the implementation of methods supported by the constructivist learning theory (Adey & Shayer, 1993, 1994; Allen, 2006; Anderson, 2002; Bennett et al., 2006; Dorph et al., 2011; Karplus, 1977, 1964, 1962; Karplus & Thier, 1969; Michaels et al., 2008; Minner et al., 2010; NRC, 2007; Shymansky et al., 1990). Constructivist learning theory is based on the belief that learning occurs as learners are actively involved in the processes of meaning and knowledge construction, as opposed to passively receiving information (Driscoll, 2005). Learners are the makers of meaning and knowledge. Instruction based on constructivist learning theory should foster critical thinking, creating motivated and independent learners. This theoretical framework holds that learning builds upon knowledge that a student already has. This prior knowledge is referred to as schema by Piaget (Driscoll, 2005). As students encounter conflicting experiences, they must restructure their knowledge, something that Piaget refers to as schema accommodation (Driscoll, 2005). Bruner and Vygotsky developed similar concepts to account for changes in a child's knowledge (Driscoll, 2005). In a lesson based on constructivist learning theory, the role of the teacher is to model, coach, and scaffold learning, emphasizing learning in context, with defined thinking activities. Inquiry science instruction is consistent with constructivist learning theory; it refers to what scientists do, how students learn, and a pedagogical approach that teachers employ (NRC, 1998).

Within the United States, elementary science programs developed with National Science Foundation funding continue to be developed based on the Learning Cycle, or aspects of the Learning Cycle (Karplus & Thier, 1969; Lawson, Abraham, & Renner, 1989). The reasoning patterns developed by Karplus and Lawrence Hall of Science (1981) are no longer used. This change has come as a result of a change in our understanding of what children are capable of at a particular age or grade (Lowery, 1998; NRC, 2007). What children are capable of is the result of a complex interplay between maturation, experience, and instruction, making what children are capable of, in large part, based on their opportunities to learn, rather than a fixed sequence of developmental stages (NRC, 2007).

The Schwab scale, originally developed in 1962, further defined inquiry by the level of student involvement in the process (Rezba, Auldridge, & Rhea, 1999; Schwab, 1962). These levels became known as confirmation inquiry, structured inquiry, guided inquiry, and open inquiry.

- Confirmation inquiry is the lowest level of inquiry. During confirmation inquiry, students are working to confirm a principle through an activity in which the results are already known in advance (Rezba et al., 1999).
- Structured inquiry is used to investigate a question that the teacher has presented though a prescribed procedure. The students collect data, and develop a conclusion based on results. The results are not known prior to the investigation (Rezba et al., 1999).
- Guided inquiry is used to investigate a teacher-presented question, using student developed/selected hypothesis, procedures, data collection methods, and analysis (Rezba et al., 1999).
- Students form their own conclusions based on their data. The student-developed criteria is typically checked by the teacher before the student progresses on to investigating (Rezba et al., 1999).
- Open inquiry is the highest level of inquiry. In this form, the students develop their own question, method, and solution. The teacher still typically checks the student-developed criteria before allowing the students to progress on to the investigation (Rezba et al., 1999)

Using the more than 50 years of research on high-quality elementary science to guide them, Michaels et al. (2008) took a step, under the direction of the National Research Council, to recognize the vital connection between content and process skills in elementary science instruction. They redefined high-quality instruction in terms of science practices, rather than inquiry-base instruction. Science practices encompass all types of inquiry instruction. Michaels et al. (2008) defined high-quality science instruction as occurring when, “conceptual understanding is linked to the ability to develop or evaluate knowledge claims, carry out empirical investigations, and develop explanations” (p. 35). High-quality instruction that involve students deeply in science practices can be divided into four strands. These four strands include: understanding scientific explanations; generating scientific evidence; reflecting on scientific knowledge; and participating productively in science (Michaels et al., 2008).

Each of these four strands requires further description to develop a full understanding of what they encompass. Within each of the strands, learning should be based on developmental appropriateness for the student.

- Strand 1: Understanding Scientific Explanations. Students need to know, use, and interpret scientific explanations of the natural world. Students should not be taught to simply memorize facts and definitions. Instead, learning should emphasize concept acquisition. Students should be taught how to apply and connect new knowledge to prior knowledge, interests, and experiences (Michaels et al., 2008).
- Strand 2: Generating Scientific Evidence. Strand two focuses on scientific reasoning. The aim should be to develop students’ knowledge and skills to guide them in building and refining models and explanations, designing and analyzing investigations, and constructing and defending arguments with evidence. Teachers should guide students in learning to ask questions, deciding what to measure, developing measurements, collecting data from the measures, organizing data, interpreting and evaluating the data, and using

results to develop and refine arguments, models, and theories (Michaels et al., 2008).

- Strand 3: Reflecting on Scientific Knowledge. Students should be exposed to the scientific process enough that they begin to understand that scientific knowledge builds over time and can be revised as new evidence emerges, scientific knowledge should be viewed as an evidence based body of knowledge. Students should recognize this characteristic in their own predictions or explanations as they revised their thinking based on newly observed evidence, increased content knowledge, or development of a new model (Michaels et al., 2008).
- Strand 4: Participating Productively in Science. Students should develop a proficiency in science from their participation. At a mastery level, they should be able to represent their scientific ideas, use scientific tools, and communicate about science with their peers (Michaels et al., 2008).

These four strands outlined by Michaels et al. (2008) were used by the National Research Council (2012) to develop *A Framework for K-12 Science Education*. This framework was then used to guide the development of the *Next Generation Science Standards (NGSS)* (NGSS Lead States, 2013). Developers of the *NGSS* are seeking approval nationally. Currently the NGSS has been adopted by nine states (California, Delaware, New Jersey, Rhode Island, Kansas, Kentucky, Maryland, Vermont, and Washington) and endorsed by the National Science Teacher Association (NSTA).

The classroom-level research that has dominated elementary science education research since the 1960s, has been successful in defining high-quality elementary science instruction, and in developing the K-12 frameworks for science instruction and standards for implementing science instruction (Bredderman, 1974, 1983, 1985; Furtak et al., 2012; Karplus, 1962, 1964, 1977; Karplus & Thier, 1969; Klentschy et al., 2001; NGSS Lead States, 2013; NRC, 1998, 2005, 2007, 2012; Shayer & Adey, 1981, 2002; Schwab, 1962; Shymansky et al., 1983; van Benthem et al., 2008; Vanosdall et al., 2007). Unfortunately, despite these well developed understandings of why elementary science is important and what high-quality instruction includes, there has been little change in elementary science instruction over the last fifty years.

Leadership in Elementary Science, the School Level Theoretical Framework

Lack of change, despite overwhelming evidence in favor of inquiry-base elementary science instruction, has prompted research to take a different direction, looking for other influences on change in elementary science at the classroom level. Research into the area of instructional leadership has found that instructionally effective schools have principals who have become the primary instructional leader in their school, and the presence of an organizational phenomenon of collective action, an agreed-on purpose, where teachers perceive they are part of something that is beyond them (Glickman, 1990). Bamburg and Andrews (1990) described effective instructional leaders as the following: a resource provider that is knowledgeable about curriculum and instruction; an instructional leader that sets expectations for continual improvement of instructional programs and actively engages in staff development as well as encourages the use of different instructional strategies; an effective communicator that models commitment to school goals and articulates a vision of instructional goals and a means for attaining these goals; provides a visible presence in classrooms, collaborative meetings, and is accessible. Each of these factors is key in developing principals who are able to become key participants in helping students achieve.

Instructional leadership theory is based on the belief that instructional quality is one of the most important factors in effective teaching. Without quality instruction, school reform is not possible. Instructional leadership includes all actions that a principal performs or delegates for the purpose of promoting growth in student learning (DeBevoise, 1984). By making instructional quality the top priority, the principal encourages educational achievement and makes that vision a reality. As an instructional leader, principals work with teachers to define educational objectives, set school-wide goals, provide the necessary resources for learning, create new learning opportunities for students and staff, and provide effective feedback that is consistent with and helps to shape quality instruction in their teachers (Wildy & Dimmock, 1993). Instructional leadership theory holds that the leader is a key element to instructional reform.

Current elementary science research has begun to look toward school leadership and external resources to examine how they influence student achievement in elementary science. Research with a primary focus on the principal’s influence on elementary science instruction is still new and only a few studies have been conducted. Research on the school level includes work by Spillane et al. (2001), who conducted a qualitative study on schools in poverty (60% FRL or higher) in the process of educational reform. Spillane et al. (2001) looked at distributed leadership, focusing on human resources, social capital, and physical resources. They found that not all elementary schools achieved success in the same manner, and that some schools that had resources, both social and capital, were ineffective in reform because they were unable to activate their resources. Spillane et al. (2001) also found strong evidence that support from positional leaders is crucial in activating and sustaining school-wide reform. Research by Lanier (2008) and Casey et al. (2012) found that in order for elementary science programs to match the message of reform, principals as instructional leaders are integral. Based on the work by Casey et al. (2012), Lanier (2008), and Spillane et al. (2001), it is apparent that the effect of leadership within the school cannot be discounted when looking for influences driving low-SES schools' achievement.

Underrepresentation in Science, a Function of Socioeconomics

The National Assessment for Educational Progress (NAEP) continues to report a significant gap, nationally, in science education between low and high socioeconomic students (NCES, 1992, 1997, 2011). Idaho's NAEP results mirror this trend (NCES, 2011).

Despite these findings, some schools are able to overcome the challenges associated with low socioeconomics and achieve at high levels in all curricular areas, including science (Haycock, 1998; ISDE, 2011a, 2012a, 2013a; Kane & Cantrell, 2009; Konstantopoulos & Borman, 2011). Few studies that have sought to examine how, within a culture of low socioeconomics, some schools are able to achieve and out-perform their high-socioeconomic counterparts. This may stem from the need to first question the well-accepted Coleman study (Coleman et al., 1966). Coleman et al. (1966) identified socioeconomic status (SES), the hierarchical ranking of individuals or families based on access to jobs, wealth, assets, power, and social status (Mueller & Parcel, 1981), as a predictor of academic achievement and social effectiveness. The Coleman report was authorized under the 1964 Civil Rights act and was the second largest social science research project in history, with 600,000 students and 4,000 schools participating nationally. Coleman et al. (1966) reported,

> School brings little influence to bear on a child’s achievement that is independent of his background and general social context; and that this very lack of an independent effect means that the inequalities imposed on children by their home, neighborhood, and peer environment are carried along to become the inequities with which they confront adult life at the end of school. (p. 325)

This finding was unsuccessfully challenged, until the meta-analytical research on the relationship between SES and academic achievement by White (1982) and by follow-up research by Sirin (2005). White (1982) and Siren (2005) showed the key to student achievement was not as simple as looking at socioeconomic status. White (1982) found only a weak correlation between the traditional measures (using one or more indicators of parents’ income, educational attainment, or occupational level) of SES (with the student as the unit of analysis) and academic achievement, but a strong correlation with grade level and home environment. Sirin’s (2005) findings revealed a moderate to strong correlation between SES and academic achievement. Recent research by Brockmeier, Starr, Green, Pate, and Leech (2013) found school-level variables do affect elementary school student achievement; however, the percentage of FRL was a stronger predictor of an elementary school’s academic achievement. For this reason, it is important to evaluate not only school and classroom-level influences, but how low-SES high-achieving elementary science programs have overcome the effects of low SES as a primary indicator of students’ achievement (Andrews & Soder, 1987; Firestone & Wilson, 1989; Kannapel & Clements, 2005; Siegrist, Weeks, Pate, & Monetti, 2009).

Additional research into the effects of socioeconomic status and student achievement, conducted by Hoy and Sabo (1998), found school climate has significant independent effects on academic achievement that rival even SES. Wenglinsky (2000) found, through the use of the 1996 NAEP study data, while SES was an influential predictor of achievement (0.75 standard deviations), when multiple aspects of teacher quality were taken into account teacher quality had about as strong an influence in science achievement (0.74 standard deviations).

Since the work of Coleman et al. (1966), Hoy and Sabo (1998), and White (1982), many researchers have conducted input-output and value-added research searching for ways in which teachers, teaching methods, school culture, and resources can overcome the effects of socioeconomics (Haycock, 1998; Kane & Cantrell, 2009; Konstantopoulos, 2011). Reform models within the United States attempting to refute the findings of Coleman et al. (1966) are not wide spread (Fryer, 2011, Secada et al., 1998). Idaho is no exception to this trend (Parrett & Budge, 2012).

Oakes et al. (1990) and Sirin (2005) both concluded that the quality of the learning opportunities children have access to is strongly related to the child’s family and community location in the socioeconomic structure. Access to learning opportunities are affected directly, by providing resources at home, and indirectly, by providing the social capital. Family SES also helps determine the kind of school and classroom environment to which students have access. Low-income students have access to fewer material resources and fewer qualified teachers who focus on developing inquiry and problem solving or promoting active involvement in mathematics and science (Banilower et al, 2013, Inverness Research Associates, 2007; Oakes et al., 1990; Weiss et al., 2001).

National testing has indicated that a gap exists within the United States, and in Idaho. This gap continues to persist between students of low and high socioeconomic status (NCES, 1992, 1997, 2011). The *National Assessment of Educational Progress* or NAEP is the assessment that the United States uses to gauge both state-level and national-level performance in elementary science.

Measuring Elementary Science Achievement

There are few measurement instruments universally used to assess science in Idaho. In Idaho, students participate in the *National Assessment of Educational Progress* (NAEP), as available, and in the science *Idaho Standards of Achievement Test* (ISAT) given in the fifth, seventh, and tenth grades. I will discuss each of these assessment measures, and the viability of each of these as a measure of elementary science achievement.

The National Assessment of Educational Progress

The NAEP is used in the United States as a national tool aligned to the *National Science Education Standards* (NRC, 1998) and *Benchmarks for Scientific Literacy* (AAAS, 1993a) to measure science content knowledge and science practices. Content knowledge is measured in physical science, life science, and earth/space sciences. Science practices measure students' ability to identify science principles, use science principles, use scientific inquiry, and apply technological design. The NAEP science assessment is a comprehensive test that contains paper-pencil items, hands-on performance tasks, and interactive computer tasks. The NAEP science test is given every four years in the fourth grade. NAEP scores are available at the state level and national level (NCES, 2012).

In 2009, the NAEP report on science continued to see low-income students, as identified by qualification for a Free and Reduced Lunch (FRL) program, with less access to material resources in science and less qualified teachers. The science NAEP also reported an achievement gap at grades 4 and 8 between students from higher and lower-income families in both the hands-on tasks, interactive computer tasks, and the paper-pencil test. When broken down to state levels, Idaho has one of the smallest SES achievement gaps in the United States (-15.43 points between scale scores), second only to Maine (-14.86 points between scale scores), with the national average at 29 points. An achievement gap is also noted in Hispanic students, with a mean score that was 31 points lower than white students. This performance gap was similar to the national average (32 points) (NCES, 2011).

Although the NAEP test is a good test for providing a big picture of how our schools are performing at the state and national level, it is not useful for providing student, building, or even district-level data. The only universally given science assessment given to students in elementary school within the state of Idaho is the science ISAT.

The Science Idaho Standards of Achievement Test

The science ISAT is given annually in the state of Idaho to elementary students in the fifth grade. Scores are available at the individual student level, classroom level, school level, district level, and state level. The science ISAT assessment measures understanding of the nature of science; content knowledge; understanding of personal and social perspectives; and use of technology. Content knowledge is tested over life science, physical sciences, and earth/space systems. The science ISAT assessment is a computer-based assessment composed of multiple-choice items that are aligned to the Idaho content standards (ISDE, 2007a). Analysis of the fifth grade science ISAT test found 50% of the assessment questions are composed of recall questions (Depth of Knowledge - Level 1), 29% are made up of basic application of skill/concept (Depth of Knowledge - Level 2), 21% are made up of strategic thinking questions (Depth of Knowledge - Level 3), and 0% are extended thinking questions (Depth of Knowledge - Level 4) (ISDE, 2007d). The reviewers, composed of representatives from Idaho, national experts, and a national psychometrician, found the questions to be consistent with the Idaho content standards. Inter-rater reliability between the eight reviewers was found to be 0.80 (Wang et al., 2007). The science ISAT assessment has an emphasis on recall of facts, with only 21% of assessment elements focused on strategic thinking.

State-developed science tests, like the science ISAT, do not directly measure higher-order thinking skills, which has lead to concerns that high-achievement on these tests may only be identifying successful teaching to the test. In response to this concern, Kane and Cantrell (2009) conducted research that studied students assigned to groups of teachers over a three year time span. The study occurred in six MET project districts across six states. Teacher effectiveness calculations were created for each teacher based on past student performance in mathematics. If teachers test scores fluctuated greatly from year to year, this reduced the teacher predictive impact on student achievement. Students were randomly assigned to 1,181 of the participant teachers and given tests for higher-order thinking and their standard state assessment. What the MET project found was that the group of teachers with high predictive values continued to produce high gains on state assessments for mathematic, with randomly assigned students the third year. Even more importantly, the students with high gains on the state test also consistently scored high on the higher-order thinking tests (Kane & Cantrell, 2009, 2013;

Kane, McCaffrey, Miller, & Staiger, 2013). The MET study found moderate correlations between different sections of the same class taught by the same teacher, for both the state assessment and for the higher-order thinking tests, as well as for different academic year state achievement test data for the same teacher (see Table 1) (Kane & Cantrell, 2009).

Table 1. Teacher Value-added Correlation on Various Assessments

Type of Test	Different Section		Prior Year	
	Total Variance	Correlation Coefficient	Total Variance	Correlation Coefficient
State Math Test	0.05 (0.23)	0.38	0.4 (0.20)	0.40
BAM Test (Higher-order thinking test)	0.07 (0.27)	0.30		

The correlation value was approximately the same for students within different sections of the same class (0.38) as it was for students from the previous year (0.40), indicating that the teacher’s effect on students was shared similarly between classrooms in the same year as between academic years (Kane & Cantrell, 2009).

The MET study revealed moderate correlation coefficients between students’ performance on state achievement tests and their performance on higher-order tests, for the same teachers (see Table 2). The higher-order tests used included the Balanced Assessment of Mathematics (BAM) test for math.

Table 2. Assessment Pairwise Correlations with Teacher Value-Added

Type of Test	Value-Added State Test		Value-Added on Higher-Order Test
	Different Section	Prior Year	Different Section
Value-Added State Math Test	0.38	0.40	0.54

The conclusion of the MET study was that groups of teachers who consistently produce students with gains on states tests also promote deeper conceptual understanding in their students (Kane & Cantrell, 2009). Although state tests are only proxy assessments and do not test for higher-order thinking directly, the science ISAT should provide a fair amount of insight into identifying schools that are high achieving in Idaho. By identifying schools that showed consistent high achievement over a three year span on the science ISAT, I anticipated that I would be able to identify schools developing students' higher-order thinking skills in a similar manner. This assumption is contingent on Kane and Cantrell's (2009) findings being consistent for other curricular areas, such as science, and for grade-level data from the same schools, rather than groups of teacher-level data taken across six different schools in six different states.

The standard error of the science ISAT is described in Table 1 (ISDE, 2011b, 2012b, 2013b). The standard error on the fifth grade science ISAT, over the last three years, has been fairly consistent. The reported standard errors, however, show that actual science ISAT scores can deviate plus or minus 3.36 – 4.13 points from the reported scores. These deviations vary by score band, as indicated in Table 3.

Table 3. Standard Error for the Fifth Grade Science ISAT

	2011– 5th Grade Science ISAT	2012 – 5th Grade Science ISAT	2013 – 5th Grade Science ISAT
Overall	3.962	3.967	3.960
Advanced/Proficient	4.13	4.13	4.10
Proficient/Basic	3.41	3.40	3.36
Basic/ Below Basic	3.43	3.40	3.41

Analysis of the 2012 ISAT data shows that the percentage of schools that are performing at the *basic* level on the fifth grade science ISAT is far greater than any other discipline. A school's rating of *basic* is an indicator that students are only able to:

> Demonstrate a limited understanding of how the world around them works. Students have a minimal understanding of how to use multiple observations, data, models, and measurement systems to make predictions and inferences during scientific inquiry. Students demonstrate a limited understanding of simple

> systems, properties of matter, basic cell structure, Earth interactions, the rock cycle, basic environmental issues, the relationship between science and technology, and natural resources. Understanding these scientific concepts allows the student to more fully understand the world around them (ISDE, 2007c, para 3.).

Thirty-four schools, or 10% of Idaho's elementary schools, are performing at the *basic* level on the fifth grade science ISAT, compared to eight schools (2%) in mathematics, one school (0.3%) in reading, and 4 schools (1%) in language (ISDE, 2012a). Each of these schools has fifth grade FRL populations that range between 28.95% and 100% (ISDE, 2012a). Although all the schools performing at *basic* or *below basic* on the ISAT have high FRL populations, there are many schools with similar FRL populations that are achieving at high levels in all curricular areas, including science (ISDE, 2012a). In addition, only a small number of the schools performing in the *basic* range were schools with populations of limited English proficient (LEP) students, which included 11 underperforming elementary schools in science (scoring below proficient), one elementary school in mathematics, one elementary school in reading, and two elementary schools in language (ISDE, 2012a). Interestingly, 59% of schools whose fifth grade ISAT scale scores fell into the *advanced* level had fifth grade classes that were composed of 30-67% FRL. Achievement at the *advanced* level is an indication that students in these schools are able to:

> Consistently demonstrate the ability to use their understanding of the world around them to solve real-world problems. Students understand how to use multiple observations, data, models, and measurement systems to make predictions and inferences during scientific inquiry. Students demonstrate a clear understanding of multiple systems, characteristic differences of matter, basic cell structure, Earth interactions, the rock cycle, complex environmental issues, the relationship between science and technology, and natural resources. Understanding these scientific concepts allows the students to more fully understand the world around them. (ISDE, 2007c, para.1)

Ninety-four percent of the top third of schools performing at the *proficient* level on the fifth grade Science ISAT had between 30-87% of students qualified for FRL (ISDE, 2012a). Achievement at the *proficient* level is an indicator that students are able to:

> Demonstrate a clear understanding of how the world around them works. Students have an understanding of how to use multiple observations, data, models, and measurement systems to make predictions and inference during scientific inquiry. Students demonstrate a general understanding of simple systems, properties of matter, basic cell structure, Earth interactions, the rock cycle, simple environmental issues, the relationship between science and technology, and natural resources. Understanding these scientific concepts allows the student to more fully understand the world around them. (ISDE, 2007c, para 2)

This study focuses on success already occurring within Idaho schools in spite of their socioeconomic status. This success was identified by finding both low and high-SES schools with consistent high science achievement on the fifth grade science ISAT over a three year span. Without a clear predictor of why some schools across the state are achieving so highly, under difficult circumstances, it was important to evaluate both the school and classroom-level influences on elementary science success. This evaluation occurred by setting Idaho schools alongside a predictive model or standard for elements required to achieve system-wide success in elementary science education, and looking to see which of these elements are occurring within these successful Idaho elementary science programs.

Keys to Achieving Elementary Science Reform

A model or standard of driving system-wide achievement in elementary science education does not currently exist. Research on reform in elementary science instruction has identified several keys to achieving high-quality elementary science reform

(Inverness Research Associates, 2007). These key elements can be broken into four categories: Programs and Practices; Teacher Background and Development; Instructional Leadership and Mandate; and Assessment and Feedback (Inverness Research Associates, 2007). Each key element is defined in the following way:

- *Program and Practice*: Program and Practice encompasses both the quality and quantity of the adopted instructional program and instructional practice within a school. A quality program is identifiable by the adoption, implementation, and support of high-quality instructional materials and instructional practices that meet state and district standards, and are consistent with the higher-order vision of the National Science Standards or the Next Generation Science Standards. The quantity of a program is identifiable by the number of hours dedicated to weekly instruction of science (Inverness Research Associates, 2006a, 2006b, 2007; St. John et al., 2007).
- *Teacher Background and Development*: Teacher background encompasses a teacher's years experience as an educator, and their formal education in teaching pedagogy and science content. Teacher development comes from the access to professional development that focuses on both pedagogy and content. The highest quality PD comes from sustained professional development (50+ hours) that promotes collaborative approaches, builds strong relationships among teachers, connects to classroom practice, and focuses on teaching and learning specific academic content (Heenan & Helms, 2013).
- *Instructional Leadership and Mandate*: Instructional leadership encompasses all actions performed or delegated by a leader for the purpose of supporting teachers'

development and promoting student growth in science. This instructional leadership in science should extend from positional leaders to shared leadership roles within the school (DeBevoise, 1984; Spillane et al., 2001; Inverness Research Associates, 2006a, 2006b, 2007; Casey et al., 2012). Instructional mandate is the requirement of a school and its teachers to implement science instruction, encompassing the quality of instruction and the quantity of instruction (Inverness Research Associates, 2006a, 2006b, 2007; St. John et al., 2007)

Assessment and Feedback: Assessments are a method of establishing evidence of students' ability to use scientific practices, apply their understanding of crosscutting concepts, and draw on their understanding of specific disciplinary ideas, over time (Pellegrino et al., 2014). Student assessment should come from a variety of approaches, including: diagnostic, formative, summative, and performance. Data collected from these assessments provides continuous feedback on a teachers' instructional effectiveness, their students' learning, and should be used to make data-driven decisions about the refinement of curriculum and instructional practices (Inverness Research Associates, 2007; Pellegrino et al., 2014).

The presence of evidence indicating implementation of each of these key elements to elementary science reform may serve as a predictor of high science achievement within elementary schools in Idaho. Each of these key elements to the elementary school reform can be evaluated at the school and classroom level (see Figure 1). The primary influence at the classroom level comes from the teacher. The primary influence at the school level comes from the school administrator. Both the classroom level and school level are vital to establishing a successful elementary science program.

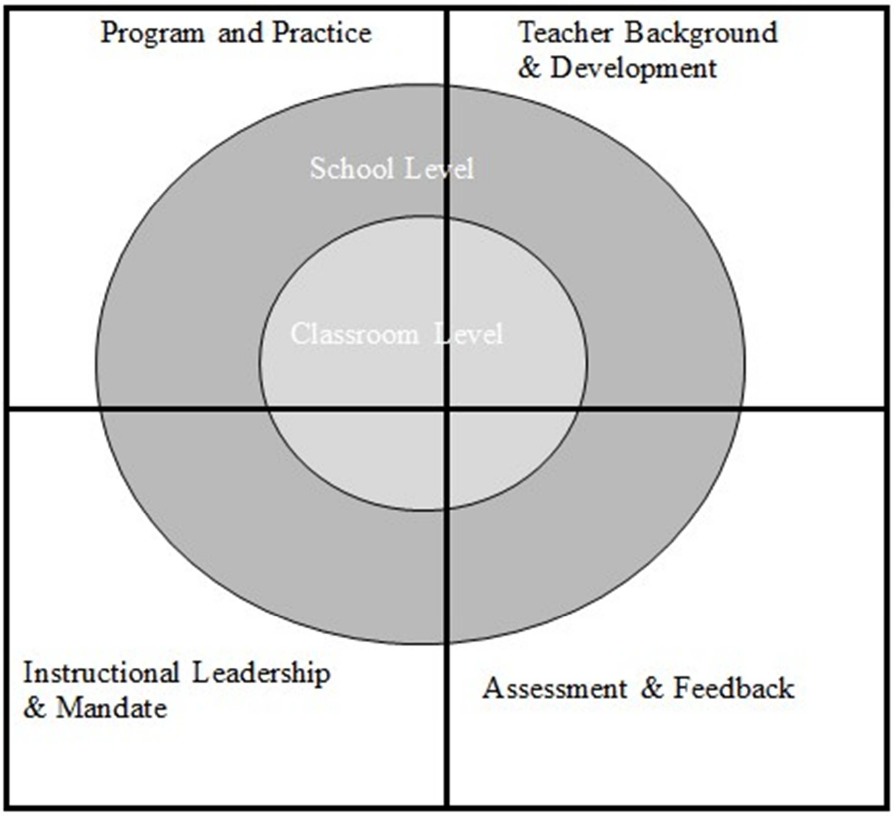


Figure 1. Implementation of the Key Elements at the School and Classroom Level

Inverness Research Associates (2007) identified the key elements as important to achieving elementary science reform. In addition to their 25 plus years of research that went into the identification of these key elements as vital, there are many studies that support and complement their work when key elements are evaluated at both the school and classroom level. I will begin by first discussing the classroom level within the context of the key elements of elementary school reform, followed by a discussion of the school level within the context of the same key elements.

The Classroom Level

Teachers are central to science reform (Glickman, 1990; Levitt, 2001; Mechling & Oliver, 1982; NRC, 1998; Woodbury & Gess-Newsome, 2002). In a synthesis of over

500,000 studies, Hattie (2003) calculated that 30% of the variance in student achievement can be attributed to teacher influence. Hattie (2003) further found that master teachers can affect student performance on standardized tests by +1.25 standard deviations. Hattie (2003) concluded, “It is what teachers know, do, and care about that makes a difference, these things are powerful in this learning equation” (p. 2).

Programs and Practices

Programs and practices incorporate what teachers do. What teachers do includes how much time they spend in implementing programs and practices, as well as how they implement programs and practices of science instruction. Time spent on science instruction is inarguably important to increasing achievement in science. Based on an analysis of the 2009 fourth grade NAEP science scores, conducted by Blank (2012) for the Noyce Foundation, instructional time for science has dropped 2.3 hours per week since 1994. In 2009, the average time spent on science varied across the United States, ranging from 1.9 hours per week in Oregon elementary schools to 3.8 hours per week in Kentucky elementary schools. According to the NAEP results, Idaho elementary schools spend an average of 2 hours per week on science instruction at the fourth grade level. When Blank(2012) compared 2009 fourth grade science NAEP scale scores to the number of hours spent per week on science instruction to the percent of students qualified for Federal Free and Reduced Lunch (FRL), he found a 12-point increase in states where FRL qualified students were exposed to four or more hours of science per week. Additionally, Blank (2012) found that in states where schools were reporting a higher mean of science instruction per week, he also found that teachers reported a higher frequency of hands-on science activities. Kentucky, for example, reported 3.8 hours of science per week. Seventy-six percent of the teachers surveyed there indicated that hands-on science activities occurred every day, or once or twice a week. In Idaho, where only a mean of 2 hours per week of science instruction was reported as occurring, only 35% of the teachers surveyed reported implementing hands-on science instruction daily, or once or twice a week. Idaho teachers reported one of the lowest frequencies of hands-on science activities use in the nation on the 2009 NAEP survey, along with: California, Hawaii, Mississippi, Oklahoma, Oregon, Tennessee, and West Virginia. By comparison, Kentucky's 2009 NAEP scale score on the fourth grade science test was 161. Idaho had a scale score of 154. Nationally, students exposed to less than one hour per week of science instruction and eligible for FRL services scored an average of 126, and students who were not eligible scored 154 on the science NAEP in 2009. Nationally, students who were exposed to four or more hours of science instruction per week and eligible for FRL scored a mean of 138; those who were not qualified scored a mean of 166 on the science NAEP in 2009 (Blank, 2012). The data from the science NAEP begins to show us that the quantity of science instruction at the elementary level matters.

In addition to quantity, the quality of the science instruction implemented is also important. The use of well-written curriculum and good instructional materials greatly improves the quality of science teaching. A study on Local Systematic Change (LSC) by Banilower, Boyd, Pasley, and Weiss (2006) found that when teachers implement well-designed materials in the way they were originally intended, the lesson was more likely to be highly rated on providing significant and worthwhile content, providing developmentally appropriate content, and for portraying science as a dynamic body of knowledge. The use of good materials as part of a district program greatly improves the quality of science teaching. The vast majority of elementary classrooms in the United States do not have this level of support, and the teachers are forced to improvise lessons and gather their own materials. If the results of this study hold true, only 11% of teacher-generated lessons will be of high-quality (Banilower et al., 2006). High-quality curriculum and instructional materials are important. A high-quality science program should incorporate all four strands of science instruction as established by Michaels et al. (2008). These strands include: understanding scientific reasoning, generating scientific evidence, reflecting on scientific knowledge, and participating productively in science.

Teacher Background and Development

Teacher support and development, comes in many forms: Professional Learning Communities (PLCs); professional conferences; state, district, and school-level in-service; institutes; university courses and workshops; and on-line professional development, professional blogs, and tutorials. A survey of 215 teachers (39% elementary teachers) from across Idaho found that teachers have distinct preferences for whom they seek out for content and pedagogical support. For content support, teachers prefer, in rank order: (1) professional development meetings, (2) teachers in their building, (3) websites, (4) teachers in their district, (5) an administrator in their building, (6) a master teacher/mentor, (7) online forums, (8) online communities (Nadelson, Seifert, Hettinger, & Coats, 2013). When asked about pedagogical support, teachers were more likely to use a website and less likely to request help from a master teacher, mentor, or administration. They were least likely to seek help from an online forum or online community (Nadelson et al., 2013). Nadelson et al. (2013) concluded that teachers most often access people they know and are physically present for support.

Professional development provides the opportunity to reflect on teaching practices, and develop both content knowledge and pedagogical skills. A recent survey of California educators, administrators, and districts conducted by Dorph et al. (2011) found that although almost 90% of elementary teachers felt prepared to teach English language arts, only one third of those surveyed felt prepared to teach science. Despite this finding, professional development for elementary school teachers in science is scarce. More than 85% of teachers surveyed had not received any science-related professional development in the last three years (Dorph et al., 2011). In order to make science more accessible to the elementary school teachers, professional development is key to increasing content knowledge and pedagogical skills.

Instructional Leadership and Mandate

Teachers can play an integral role in elementary science leadership, formally and informally as teacher leaders. Their roles can range from organizers of the annual science fair, or ordering supplies and instructional materials, to coaching instruction (Spillane et al., 2001). Spillane et al.'s (2001) qualitative study found that leadership for elementary science instruction came largely from teachers, who did not have official designations or receive monetary resources, release time, or reduction in teaching responsibilities. This study showed that although we think initially of the principals role in instructional leadership, there is also evidence that teachers play a critical role in leadership that helps move schools to high achievement.

Assessment and Feedback

The body of research conducted since the publication of the *National Science Education Standards* (NRC, 1998) has indicated that developing deep conceptual understanding is more productive for future learning than memorizing discrete facts. Learning experiences should be designed over multiple years with coherent progressions in mind (Black & Wiliam, 2009; Heritage, 2010; NRC, 2012; NGSS Lead States, 2013; Pellegrino et al., 2014; Perie, Marion, & Gong, 2007). To achieve a comprehensive assessment of student science understanding, teachers need to balance measuring students' abilities to implement scientific practices, measuring students' ability to apply crosscutting concepts, and measuring students' ability to understand core ideas (Pellegrino et al., 2014).

To measures students' abilities to implement scientific practices, students must be given the opportunity to engage in scientific practices. By allowing students to engage in scientific practices, teachers allow them the opportunity to truly understand the core ideas. In order to assess students in scientific practices, teachers need to ask students to: answer and ask questions; develop and use models; plan and carry out investigations where they are given opportunities to analyze and interpret data; use mathematics and computational thinking; construct explanations and design solutions; engage in argument from evidence; and obtain, evaluate, and communicate information (Pellegrino et al., 2014).

To measure students' ability to apply crosscutting concepts, teachers need to first help students develop links between knowledge from the various disciplines. As students develop these links, they begin to develop an organizational framework for connecting knowledge across disciplines and developing an integrated understanding of what they learn in different settings. Examples of crosscutting concepts that should be assessed at varying developmental levels include identifying patterns and creating organized meanings from them; developing an understanding of cause and effect; and conservation of energy and matter (Pellegrino et al., 2014).

To measure students understanding of core ideas, teachers need to evaluate core ideas within physical science, life sciences, earth and space sciences, and engineering, technology, and applications of science. Evaluation of core ideas, however, should not focus on scientific details; rather, it should focus on helping students build sufficient core knowledge and abilities to provide them a scaffold to which they are able to attach, acquire, and evaluate new information on their own as they continue their education (Pellegrino et al., 2014). In other words, the focus of core ideas is building a framework for a deeper understanding of the crosscutting concepts and scientific practices.

To reflect each of these three dimensions of learning, assessment tasks must be designed to provide evidence of students’ ability to use scientific practices, apply their understanding of crosscutting concepts, and draw on their understanding of specific disciplinary ideas, over time (Pellegrino et al., 2014). No single assessment type is capable of assessing all three dimensions of learning simultaneously, so teachers need to implement a variety of assessment activities and approaches. These assessment tasks must be representative of: what is valued; the curriculum objectives; the instructional methods; and the purpose for the assessment (Hanna & Dettmer, 2004). Assessment is often thought about as an instrument to evaluate if change has occurred, but the purpose of some forms of assessment is to enhance learning. Assessment comes in many forms:

diagnostic, formative, summative, and performance. Different types of assessment are used for different purposes.

The purpose of a diagnostic assessment is to identify a students' current understanding of a subject, identify students' misconceptions, and identify skill sets and capabilities. Examples of common diagnostic assessments include pre-tests, self-assessments, discussion board responses, and interviews.

The purpose of a formative assessment is to improve student learning and reduce the gap between the targeted student performance and observed student performance (Bell & Cowie, 2001; Ruiz-Primo & Furtak, 2007). Formative assessment allows teachers to evaluate key points and check for student understanding before, during, and after instruction (Ruiz-Primo & Furtak, 2007). Formative assessment can be more formal, such as quizzes, tests, and portfolios, or more informal (Ruiz-Primo & Furtak, 2007). Informal formative assessment is key to implementing teacher-led high-quality science instruction because the teacher must listen to students talk during the activity, asking students to explain their thinking, beliefs, and ideas, and requiring evidence for their thinking (Ruiz-Primo & Furtak, 2007). The key to good informal formative assessment during inquiry science instruction is to listen to students' talk during the inquiry activity (Ruiz-Primo & Furtak, 2007). The craft of questioning is key: teachers must master the difference between asking questions for the purpose of recitation and asking probing questions (Ruiz-Primo & Furtak, 2007). Informal formative assessment can take place during whole-class, small-group, or one-on-one teacher-student interactions. It is improvisational in nature and often goes unrecorded (Ruiz-Primo & Furtak, 2007). Lines may be blurred between instructional activities and assessment activities, when teachers are implementing formative assessments. Assessments may come in the form of students explaining their model designs, sharing ideas with each other in a group, or from artifacts that are the result of science activities (Pellegrino et al., 2014).

The purpose of summative assessment is to evaluate students' learning; it is product-oriented and the assessment is the final product. Examples of summative assessment include: final exams, term papers, performances, and standardized tests. Summative assessments assess the final product, so no revisions can be made. If revisions are made, learning continues, and the assessment is formative. Idaho has one statewide science assessment at the elementary level: fifth grade. This one test is not able to capture all the learning outcomes related to science, and only provides data on students' science knowledge after being in elementary school for six years. This situation is similar in many states, including California where a study by Dorph et al. (2011) found that 66% of California elementary teachers felt that they received little to no support in assessing their students' science learning. Teachers in elementary schools serving high percentages of low-SES students were more likely to report receiving limited or no support for assessing their students' science learning than teachers in elementary schools serving lower percentages of low-SES students (Dorph et al., 2011).

Traditionally, science assessments have focused on measuring students' understanding of aspects of core ideas or of science practices as discrete pieces of knowledge. Progression in learning has generally been thought of as knowing more or providing more complete or correct responses. Assessments were more likely to ask for definitions than for actual use of the practice (Pellegrino et al., 2014). Performance assessment, also known as authentic assessment or assessment tasks, requires a student to perform a task or demonstrate a skill under defined conditions, knowing that their work will be evaluated according to an agreed upon standard (Ruiz-Primo & Furtak, 2007). Performance assessments should have multiple components, including opportunities for students to engage in practices to demonstrate their capacity to apply their knowledge. Assessments should include opportunities to ask students to articulate a claim and provide justification linked to evidence (Pellegrino et al., 2014). Examples of performance assessments include open-ended or extended-response exercises, extended tasks, and portfolios.

In order for teachers to assess students on all three dimensions of learning, they should use a variety of assessment activities; they should be providing tasks with multiple components; the assessments should focus on connections among scientific concepts; and the assessments should gather information about how far students have progressed along a defined sequence of learning (Pellegrino et al., 2014). Teachers should also provide well-developed feedback to students about their performance or understanding of a concept.

Teachers use feedback to provide information to the student about their performance or understanding (Hattie & Timperley, 2007). The effective use of feedback by the teacher can assist students in comprehending, engaging, and developing a clearer understanding, and can motivate the student. Feedback has one of the greatest influences on student learning, with an effect size up to 1.13. Effective feedback must be clear, purposeful, meaningful, and compatible with students’ prior knowledge and provide logical connections to instructional content (Hattie & Timperley, 2007). The importance of classroom culture and climate is important in fostering peer and self-assessment and to allow for learning from mistakes. When feedback is combined with effective instruction in classrooms, it can be very powerful in enhancing learning (Hattie & Timperley, 2007).

The School Level

Research on the classroom level has predominated since the 1960s. Despite an understanding of why elementary science is important and an understanding of what high-quality instruction includes, there has been little change in elementary science instruction. Teachers are central to science reform (Glickman, 1990; Levitt, 2001; Mechling & Oliver, 1982; NRC, 1998; Woodbury & Gess-Newsome, 2002); however, to have great influences on student achievement, teachers need support (Hattie, 2003). Teachers cannot be held solely responsible for achieving successful science reform; "the past failures of many attempted reforms can often be explained by reformers' lack of attention to the support systems that surround a desired change" (p. 774). Despite both small and large-scale efforts to reform science education, centered on curriculum and methodological changes to instruction, reform efforts have made little difference over the past 50 years. Elementary science education reform has been experiencing the paradox of *change without difference* (Goodman, 1995; Woodbury & Gess-Newsome, 2002).

Many science education professionals have concluded that school principals have the greatest influence within the context of the school (Ediger, 1999; Greenleaf, 1982; Mechling & Oliver, 1982, 1983; Vasquez, 2005). Mechling and Oliver (1983) stated, "Principals have the power to promote or prevent innovation not because they have a monopoly on imagination or creativity, but because they have the authority to make a decision" (p. 14). These decisions can influence access to resources, professional development, high-quality instructional materials, and support. Current research on the principals' role in elementary science education is in its infancy, but the limited research indicates that principals do have an influence on science achievement in elementary schools (Brockmeier et al., 2013; Casey et al., 2012; Khan, 2012; Lanier, 2008)

Programs and Practice

Administrators play a critical role in creating the space, time, and incentives for teachers to engage with the ideas in science reform efforts and in helping teachers to critically examine their current practice. Administrators control access to budgetary resources and often make judgments about instructional materials. When there is a lack of budgeting for materials and replacement costs, instruction is affected and often it completely prevents high-quality instruction from getting off the ground (Goldsmith & Pasquale, 2002). The current economic climate in the United States has brought about deep cuts in education across the country. Idaho is no exception. These cuts have limited funds to support high-quality science programs (Dorph et al., 2011; Goldsmith & Pasquale, 2002). Teachers in schools serving higher percentages of students in poverty are even more likely to report lack of facilities and resources as a major challenge to providing science instruction than teachers from affluent schools (Dorph et al., 2011). Seeking external funding and resources to support science becomes crucial (Dorph et al., 2011; Spillane et al., 2001). However, Dorph et al. (2011) discovered that most schools do not seek out external funding.

Teacher Background and Development

Principals need to be skilled in providing support and feedback to teachers. Like teachers, principals also need to seek out professional development. Principals need to be current on the elements of high-quality science instruction. Dorph et al. (2011) provide examples of high-quality principal professional development that schools in California have implemented with success. One example involved a district science coordinator providing training to principals to familiarize them with the science instructional materials. In another case, a science coordinator provided principal support by conducting science observations with the principal. A debriefing followed these observations on what high-quality science instruction should look like and what evidence they saw of it during the observations (Dorph et al., 2011).

A principal’s ability to identify teachers who need extra support becomes crucial in schools that have large populations of low-SES, ELL, and minority students. Due to high teacher mobility in schools with high levels of diversity and low socioeconomics, teachers that are less skilled and have less experience are more highly concentrated in schools with large populations of underrepresented students. Therefore, learners traditionally underrepresented in the STEM career pipeline are most apt to be at the mercy of outdated texts and curriculum materials. Their teachers are more likely to be less able to compensate for these weak materials due to lack of content knowledge and pedagogical skills, preventing students from gaining needed skills to enter or continue down the STEM career pipeline (Berryman, 1983; National Commission on Mathematics and Science Teaching for the 21st Century, 2000).

School administrators can create a school community that actively supports science learning. Administrators can help build understanding of what highly skilled teachers are doing and encourage others to join and support them. They can help educate other teachers, students, and parents about the changes that they observe in these teachers’ classrooms (Michaels et al., 2008). Principals can create support positions, such as teacher mentors and/or science coaches who are skilled in implementing high-quality science instruction. These individuals can play a shared leadership role in the selection of instructional materials and the development of curriculum. Dorph et al. (2011) found that only 25% of schools received support in the form of replenishment centers, instructional coaches, or science specialists.

Instructional Leadership and Mandate

Science is considered a core subject in the elementary school. However, it is not assessed to the degree that reading, language arts, and mathematics are assessed. In Idaho, the science ISAT is given in fifth, seventh, and tenth grades, meeting the standard set by No Child Left Behind (NCLB). According to the Idaho State Department of Education, the science ISAT only assesses standards from the fifth, seventh, and tenth grades (ISDE, 2013c, para 6). This pattern of assessment is similar to many states throughout the United States. For this reason, it is not surprising that across the United States, science has continued to be one of the most disregarded subjects at the elementary level. It has taken on the role of a fringe subject accessed when time allows, taught intermittently and unsystematically (Ediger, 1999; Greenleaf, 1982; Mechling & Oliver, 1982, 1983; Spillane et al., 2001; Vasquez, 2005). This haphazard treatment of elementary science instruction is counterproductive in developing a foundation for intellectual development, scientific literacy, and STEM career awareness.

A national survey conducted by Weiss (1978) showed that elementary teachers taught science a mean of 17 minutes per day as opposed to about 90 minutes per day for reading. Results of the National Survey of Science and Mathematics indicate that this pattern has changed little (Banilower et al., 2013; Weiss, Knapp, Hollweg, & Burrill, 2001). In 2000, elementary teachers spent a mean of 25 minutes per day on science and 114 minutes on reading/language arts (Weiss et al., 2001). In 2012, the survey indicated that elementary teachers spent a mean of 21 minutes per day on science and 86 minutes per day on reading/language arts (Banilower et al., 2013). Weiss (1978) pointed out that elementary teachers' perceptions about their qualifications for teaching science are consistent with the amount of time they spend teaching science. Lynch et al. (2005) believed that the less skilled and less experienced the teachers, the less likely they are to use high-quality instructional practices.

Teachers need the support of their principals to remodel their instructional practices (Banilower et al., 2013; Johnson & The Project on The Next Generation of Teachers, 2007). Through effective instructional leadership, principals can create cultures of collaboration, inquiry, lifelong learning, experimentation, and reflection, resulting in greater teacher motivation, self-esteem, and reflective behavior, with increased innovation, variety in teaching, and risk taking (Blasé & Blasé, 2001; Glickman, 1990). Banilower et al. (2006) found that teachers are more likely to implement the use of science reform-based instructional materials and practices if they are supported by their principals. Blasé and Blasé (1999a, 1999b) found that principals can have a direct impact on teachers' efficacy and teacher instructional practices. This is important because we know that teacher efficacy and teacher instructional practices interact to promote student achievement (Hallinger & Heck, 1998; Pitner, 1988).

Assessment and Feedback

Principals’ use of assessment and feedback should extend to a school-wide model, as well as supporting effective practices at the classroom level. Principals should monitor and model effective use of both summative and formative assessment data within their schools, both through the use of state assessment data and by monitoring evidence of student learning during classroom observations. Development of frequent, common, high-quality formative assessments used by teachers working collaboratively together on an agreed-upon focus can result in powerful results. By building a team’s capacity to improve their programs and practices, they ensure that the curriculum is taught. They provide information about the practice of individual teachers, and they facilitate a response system for students who are experiencing difficulty (DuFour, DuFour, Eaker, & Many, 2006).

Closing the knowing-doing gap by embedding the process of acquiring new knowledge into actually doing to the task, they set their teachers up for a greater chance of success (DeFour et al., 2006). Establishing a school-wide culture of reflective practices provides opportunities for principals to evaluate the effectiveness of curricular programs within their schools on an ongoing basis and provide opportunities and guidance for teachers to participate in professional learning communities (PLC) or lesson study groups focused on science. Within these PLC or lesson study groups teachers have the opportunity to discuss science assessment and share student artifacts with their peers (DuFour et al., 2006; Pellegrino et al., 2014).

Principals need to be knowledgeable about the elements of high-quality science instruction so that they can contribute valid evaluation of teachers’ instructional practices in science. Principals need to model, providing specific feedback on instructional practices that are meaningful. They need to identify and support teachers that need increased pedagogical growth or increased background knowledge in science to be successful (National Commission on Mathematics and Science Teaching for the 21st Century, 2000; Berryman, 1983).

Summary

The key elements to elementary science reform provided a framework against which to check Idaho high science achieving elementary schools. By gathering the perspectives of the teachers and principals, I was able to identify the level of implementation of the key elements to elementary science reform, holistically, within participant high-achieving schools.

By identifying the presence of each of the key elements to elementary science reform within participant schools, this study is able to provide a road map to where Idaho needs to focus efforts for achieving high-quality science instruction and further insight into what Idaho is currently defining as high achievement in elementary science education. This study also provides a unique prospective into the differences between low and high-SES schools and value that Idaho schools currently place on science instruction in the elementary grades.

CHAPTER THREE: RESEARCH METHODS

Introduction

The purpose of this study was to discover if the four key elements of elementary science education reform were present in high science achieving elementary schools within the state of Idaho and specifically if the presence of the key elements differ between low and high-SES schools. The four key elements to elementary science reform include: Programs and Practices, Assessment and Feedback, Instructional Leadership and Mandate, and Professional Development (Inverness Research Associates, 2007).

This study sets out to answer the following questions:

Question 1: In Idaho, are all of the four key elements present in all of the high science achieving elementary schools? This question was further broken into four sub-questions:

- Is there evidence of the element Programs and Practices found within all of the high science achieving elementary schools in Idaho?
- Is there evidence of the element Teacher Background and Development found within all of the high science achieving elementary schools in Idaho?
- Is there evidence of the element Instructional Leadership and Mandate found within all of the high science achieving elementary schools in Idaho?
- Is there evidence of the element Assessment and Feedback found within all of the high science achieving elementary schools in Idaho?

Hypothesis 1: Based on three years of science ISAT results, the identified Idaho schools have consistently developed high achievers in science (ISDE, 2011a, 2012a, 2013a). As a state, Idaho has scored above the national average on the last National Assessment of Educational Progress (NAEP) test given in the elementary grades (NCES, 2011). The NAEP test is a rigorous test that tests beyond rote knowledge, making it reasonable to believe that evidence will be present in all of the highest science achieving schools in the state that indicates they are engaged in delivering all four key elements considered important to achieving success in elementary science.

Question 2: In Idaho, high science achievement can be found in both low and high socioeconomic status elementary schools. Does the evidence indicate a difference between the low and high-SES schools' implementation of the key elements to elementary science reform in Idaho high science achieving schools? This question was further broken into four sub-questions:

- Is there a difference in the implementation of Programs and Practices between Idaho low and high-SES, high science achieving elementary schools?
- Is there a difference in the implementation of Teacher Background and Development between Idaho low and high-SES, high science achieving elementary schools?
- Is there a difference in the implementation of Instructional Leadership and Mandate between Idaho low and high-SES, high science achieving elementary schools?
- Is there a difference in the implementation of Assessment and Feedback between Idaho low and high-SES, high science achieving elementary schools?

Hypothesis 2: Based on the different pressures created by socioeconomic status in low and high-SES schools, the ability to implement each of the key elements will be different in the high science achieving, high and low-SES schools.

I attempted to answer these questions and test my hypothesis using the following research design and rationale, which details a two-phase study focused on collecting data from principals at the school level and teachers and the classroom level.

Research Design and Rationale

This study was descriptive in nature, but took advantage of between-measures analysis to reveal the implementation level for each of the key elements to elementary science reform between high science achieving low and high-SES elementary schools in Idaho.

The independent variable used for the between-measures analysis was socioeconomic (SES) status, as determined by school-level Free and Reduced Lunch (FRL) qualification. This variable was broken down into high SES (25% or less qualification for FRL) and low SES (40% or higher qualification for FRL).

The dependent variables used for the between-measures analysis were the four key elements to elementary science reform. The operational definitions for each of the key elements, for the between-measures analysis, are as follows:

- *Programs and Practices*: The Programs and Practices variable investigated the time committed to science instruction, teaching practices and beliefs about application of practices, and the promotion of a culture of science education. This variable also analyzed the science textbooks or modules used, the availability of science instructional resources, and the annual funding budgeted for science. Questions and composites aligned to this variable are available in the Programs and Practices section of the teacher and principal survey tools (see Appendix C and in Table A1).

- *Teacher background and development*: The Teacher Background and Development variable analyzed teachers' pedagogical and content background and their feelings of preparedness to teach the various science disciplines, encourage students in science, and teach diverse learners in science. The variable also evaluated the perceived availability, quality, and the focus of elementary science professional development. Questions and composites aligned to this variable are available in the Teacher Background and Development section of the teacher and principal survey tools (see Appendix C and in Table A2).
- *Instructional leadership and mandate*. The Instructional Leadership and Mandate variable evaluated the presence of shared leadership and the presence of instructional leadership. The variable analyzed the extent to which the policy environment and school-level support promoted effective science instruction. The variable looked at the availability of coaching of science instruction, support for struggling teachers in science, and the presence of and participation in professional learning communities in science. The variable evaluated the presence of a mandate to provide science instruction within the schools. Finally, the variable evaluated the presence of school-level instructional observation and feedback in science instruction, as well as the presence of a school-level understanding of reform-based science instruction.

Questions and composites aligned to this variable are available in the Instructional Leadership and Mandate section of the teacher and principal survey tools (see Appendix C and in Table A3).

- *Assessment and feedback*. The Assessment and Feedback variable analyzed the methods of assessment and feedback used, by teachers, to evaluate students in elementary science. The variable evaluated the types of assessments (formative, summative, diagnostic, and performance) that teachers' use and how they change their individual student and whole-class instruction based on data. The variable also analyzed the use of school-wide monitoring of student progress in science. Questions and composites aligned to this variable are available in the Assessment and Feedback section of the teacher and principal survey tools (see Appendix C and in Table A4).

Research Design

The dependent variables used for the between-measures design were measured at the school and classroom level. The school level was assessed through the school principal's perspective, using an adaptation of the *2012 National Survey of Science and Mathematics Education: Science Program Questionnaire* (Horizon Research., 2012b). The classroom level was assessed through the teachers' perspective, using an adaptation of the 2012 National Survey of Science and Mathematics Education: Teacher Questionnaire (Horizon Research, 2012b). Each of the tools used in this study were aligned to the study questions and the key elements of elementary science reform: programs and practices, assessment and feedback, instructional leadership and mandate, and teacher background and development (Inverness Research Associates, 2007). The measurable dependent variables include nominal, interval, and ratio survey and protocol responses, as well as short answer responses and observation responses that were analyzed using qualitative coding methods.

The principal survey was administered to principals from 35 schools in 17 school districts across the state of Idaho. The principal survey was completed by 24 principals and was followed up with a survey of approximately three teachers from each of these participating schools. The teacher surveys were administered to 80 elementary teachers in third through fifth grades. Both the principal survey and the teacher survey were aligned to the four key elements of elementary science reform (Inverness Research Associates, 2007). The data collected from this study provide holistic information about school-wide and classroom-wide influences on achievement in elementary science within the state of Idaho.

Sampling Procedures

Idaho covers 83,574 square miles, but has only has 1,293,953 residents, making it a predominantly rural state. There are 366 public elementary schools statewide. The samples collected and used in this study included low and high-SES, high science achieving Idaho elementary school principals and teachers. The sample included schools from urban, suburban, and rural districts from across the entire state of Idaho.

Idaho Science Achievement Testing

In Idaho, the science component of the *Idaho Standards of Achievement Test* (ISAT) is administered annually in the fifth, seventh, and tenth grades. Scores are available at the individual student level, classroom level, school level, district level, and state level. The science ISAT assessment measures understanding of the nature of science; content knowledge; understanding of personal and social perspectives; and use of technology. Content knowledge is tested over life science, physical sciences, and earth/space systems. The science ISAT assessment is a computer-based assessment composed of multiple-choice items aligned to the Idaho content standards (ISDE, 2007a). Analysis of the fifth grade science ISAT test found 50% of the assessment questions are composed of recall questions (Depth of Knowledge - Level 1), 29% are made up of basic application of skill/concept (Depth of Knowledge - Level 2), 21% are made up of strategic thinking questions (Depth of Knowledge - Level 3), and 0% are extended thinking questions (Depth of Knowledge - Level 4). The reviewers, composed of representatives from Idaho, national experts, and a national psychometrician, found the questions to be consistent with the Idaho content standards. Inter-rater reliability between the eight reviewers was found to be 0.80 (ISDE, 2011b, 2012b, 2013b; Wang et al., 2007). The science ISAT assessment has an emphasis on recall of facts, but also assesses elements of problem solving. The standard errors of the science ISAT are presented in Table 3 (ISDE, 2011b, 2012b, 2013b).

In addition to the annual ISAT test, many districts administer the mathematics and language component of the *National Assessment of Educational Progress* (NAEP) test annually, and a random selection of Idaho schools administer the science NAEP every four years in the fourth grade. The science NAEP is used in the United States as a national tool, aligned to the *National Science Education Standards* (NRC, 1998) and *Benchmarks for Scientific Literacy* (AAAS, 1993a) to measure science content knowledge and science practices. Content knowledge is measured in physical science, life science, and earth/space sciences. Science practices measure students’ ability to identify science principles, use science principles, use scientific inquiry, and apply technological design. The NAEP science assessment makes use of paper-pencil items, hands-on performance tasks, and interactive computer tasks. The NAEP science test is given every four years in the fourth grade. The NAEP is more closely aligned to the how teachers are encouraged to teach science, however the NAEP scores are only available at the state and national level (NCES, 2012). The science ISAT is the only science assessment given statewide with scores that are available at the school level, as such this assessment was used to identify schools that are high-achieving. However, in order to be considered, schools must maintain this high-achievement standard with consistent scores across three years, which is suggestive of instruction that is occurring beyond the rote level, according to research conducted by Kane and Cantrell (2009).

Idaho High Science Achievement Sample

The populations I was interested in identifying included high and low-SES elementary schools showing consistent high performance on the fifth grade science ISAT for three consecutive years. The confounding variables: reading, language, and mathematics, were controlled for by comparing high and low-SES schools with comparable performance on the reading, language, and mathematics ISAT test. I used a non-random purposive sampling to generate my participant school sample. Purposive sampling selects sample participant schools by using strict criteria to eliminate non-participants (Johnson & Christensen, 2008; Teddlie & Yu, 2007; Tongco, 2007). The use of purposive sampling techniques was appropriate for this study because of its focus on evaluating deviant cases. The sample selected was representative of high and low-SES schools that are high achieving on the fifth grade science ISAT (Tongco, 2007), providing high internal validity, but decreasing the study's external validity. The external validity, however, could be increased by the development of a second study used to confirm the results within the context of another state (Tongco, 2007). School ISAT scores and demographics were accessed through Idaho State Department of Education's data files, available to the public through state department's website. The data used were the 2011, 2012, and 2013 *No Child Left Behind School Report of Scores and Demographics*. These data contain demographics and ISAT scale scores for reading, language, and mathematics at each grade level, and science ISAT scale scores for fifth, seventh, and tenth grades.

Schools were initially sorted using the 2012 *No Child Left Behind School Report of Scores and Demographics* file. The sort criteria order was: (1) grade: 5, 6, 7, 8, 9, 10, 11, 12, 3, 4; (2) subject: science, mathematics, reading, language; (3) science ISAT scale scores, highest to lowest; and (4) percentage of students scoring in the *Advanced* category within each school, highest to lowest. I then created a formula to calculate percent qualification for SES, based on the number of students who took the test and the number of students that qualified for FRL. By looking at the percent qualified for FRL, I color coded the data, based on schools meeting the following set criteria:

- High achievement, scale scores that fit into either *Advanced* (216+) or within the top third of *Proficient* (212-215). See Table 4 for fifth grade science ISAT scale score bands (ISDE, 2007b).
- A minimum of 30% of fifth grade students performing within the *Advanced* category on the science ISAT, to prevent a few super achievers from skewing the results.

- Fifth grade classes of 25% or less FRL qualification (high SES) and fifth grade classes of 40% or greater FRL qualification (low SES). These schools were also checked to ensure that the school-level FRL status met these criteria.
- Consistent scale scores over three consecutive years of science ISAT testing at the fifth grade level, looking at 2011, 2012, and 2013 science ISAT results.
- A minimum enrollment of 50 students at the fifth grade level, ensuring multiple teachers and reducing the statistical effects of small population sizes on percent FRL, and the effect of individual student scores on the average score.

Table 4. ISAT Science Scale Score Bands

	Advanced	Proficient	Basic	Below Basic
Science	216 and up	206-215	194-205	193-below

The criteria I used to identify low and high-SES samples were based on Title One requirements. In the state of Idaho, to receive the Title One whole-school intervention, a school must maintain Free and Reduced Lunch qualification of 40% or higher at the school level. For this reason, I used 40% or greater FRL qualification as my identifier of low socioeconomic status schools. Title One targeted assistance in Idaho is FRL qualification at the school level of 30% or greater. For this reason, I chose 25% or less FRL qualification as my identifier of high socioeconomic status.

After identifying the high and low-SES schools that met the criteria for qualification in the study, I then used the school and district codes to identify the name of each school. This allowed me to look up the school-wide percent of FRL qualification and ensure that it also met the set criteria. The 2011 school coding system was changed between 2011 and 2012, thus by having the school name, it allowed me to match up schools in the 2011 *No Child Left Behind School Report of Scores and Demographic* files. I compared the 2011, 2012, and 2013 fifth grade science ISAT scale scores of the identified schools, and eliminated any schools in which large fluctuations occurred in their scores within the three year span.

The original sample of 366 elementary schools, statewide, was narrowed to six high-SES schools and three low-SES schools within the *Advanced* RIT band (216 or higher) and 11 high-SES schools and 35 low-SES schools in the upper third of the *Proficient* RIT band (212-215), totaling 17 high-SES schools and 38 low-SES school (55 total schools). This number further decreased to 40 schools when I looked for schools with consistent scale scores on the fifth grade science ISAT over three years. These 40 schools are made up of: 14 high-SES schools with scale scores ranging between 223 and 212 on the 2013 science ISAT and 26 low-SES schools with scale scores ranging between 222 and 212 on the 2013 science ISAT. The strict criteria used for this study revealed a small sample size, precluding the use of randomized sampling, but allowed for the entire identified sample of 40 schools to be invited to participate in the study.

The participant schools are located in five out of six of Idaho's regions (see Figure 1). These schools can be further defined as residing in rural or non-rural districts, as defined by the state of Idaho (ISDE, 2013d). The state of Idaho defines rural schools as having met at least one of the following criteria: fewer than 20 enrolled students per square mile within the school district boundaries or a county in which the school district is located in an area with fewer than 25,000 residents, based on the most recent United

States census. Charter schools are considered a rural public school if where they reside is considered rural. Virtual charter schools are considered rural if at least 50% of their enrolled students reside within school districts that meet the definition of a rural school district. In my sample, 11 rural school districts (11 schools) were invited to participate and 7 non-rural school districts (29 schools) were invited to participate (ISDE, 2013d).

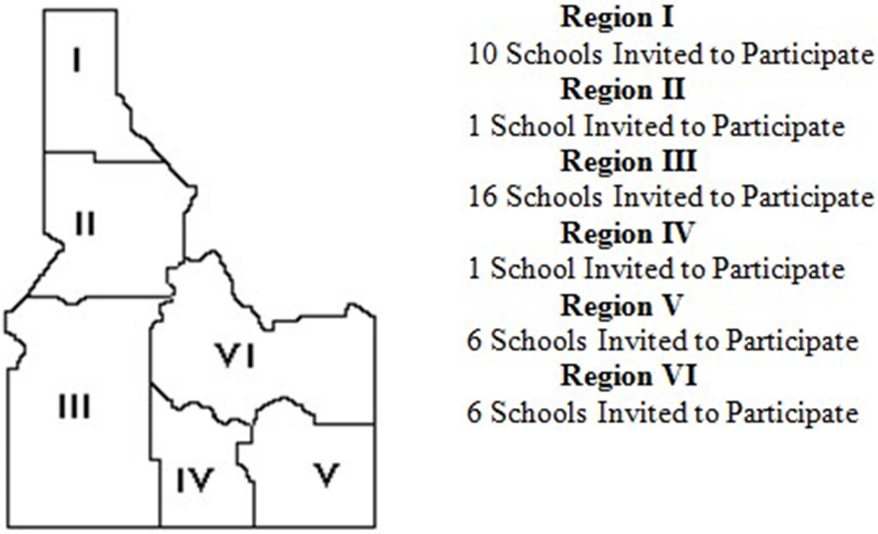


Figure 2. Schools Invited to Participate in the Study, Dispersal Map

Identifying Principal Participant Sample

I invited forty schools to participate in the study. The procedure for invitation included first requesting permission to conduct the study within each of the 19 districts. I submitted a proposal to each of the 19 districts; 17 districts chose to participate. This process reduced the school sample down to 35 schools. I contacted each of the 35 school principals via telephone to introduce myself and the study (see Appendix B). I made verbal contact with 23 of the principals and I left messages for 14 principals prior to sending the principals the Internet-based survey invitation letter (see Appendix B). I followed the initial letter and survey link with a weekly reminder letter and survey link (see Appendix B). The survey began on December 6, 2013 and concluded on January 6, 2014. Twenty-three of the invited school principals chose to participate (66%), which represents 56% of the total identified population.

Identifying Teacher Participant Sample

Schools in which the principal participated were invited to participate in the teacher survey phase of the study. I contacted the principals and asked them to provide me the names of up to six teachers in third through fifth grades, with preference given to fifth grade teachers (see Appendix B). Principals provided me with the names of one to ten names of teachers. Actual teacher responses from schools ranged from one to five completed surveys. Three schools opted out of this phase of the study. Principals provided me the names of 80 teachers in third through fifth grades. Once I received the names of teachers, I sent a letter and survey link inviting the teachers to participate in the study via e-mail (see Appendix B). I followed the initial letter and survey link with a weekly reminder letter and survey link. The survey began on March 13, 2014. I sent weekly e-mail reminders until May 6, 2014, when I sent the last reminder. I closed the teacher survey on May 9, 2014. Fifty-one teachers, out of the 80 invited, participated in the survey (64%). These teachers were composed of six third grade teachers, six fourth grade teachers, thirty-seven fifth grade teachers, and two multi-grade specialist teachers.

Measurement Instruments

The survey instruments used in this study were designed to evaluate elementary science based on the implementation of the key elements to elementary science reform (Inverness Research Associates, 2007). The measurement instruments used in this study were adapted from a robust set of national survey instruments created by Horizon Research (2012a, 2012b, 2012c). Adaptations of the original surveys were necessary in order to include assessment and instructional leadership. Other published surveys were used to influence question choices for the assessment and instructional leadership subsections (Lanier, 2008, Lanier, Gallard, & Southerland, 2009; Louis, Dretzke, & Wahlstrom, 2010; Pritz & Kelley, 2009) and for the background section (Horizon Research, 2012a). I asked several non-participant teachers and administrators to provide feedback on the instrument items. I revised the instruments based on the teacher and principal feedback to increase clarity and minimize ambiguity, while maintaining fidelity to the original constructs.

The School Level: Principal Survey

The *Science Program* survey tool for principals constructed by Horizon Research (2012b) explicitly targeted principals' knowledge of and mandate for elementary science education. The principal survey (Appendix C) is composed of 25 questions on the following topics: School Programs and Practices, Teacher Background, Support and Development, Instructional Leadership, and Assessment and Feedback (see Figure 2). An additional five background questions and one open response conclusion question were included in the survey. The survey was composed of yes/no items, five point Likert items, and fill-in items (see Appendix C). The principal survey took approximately 15 minutes to complete.

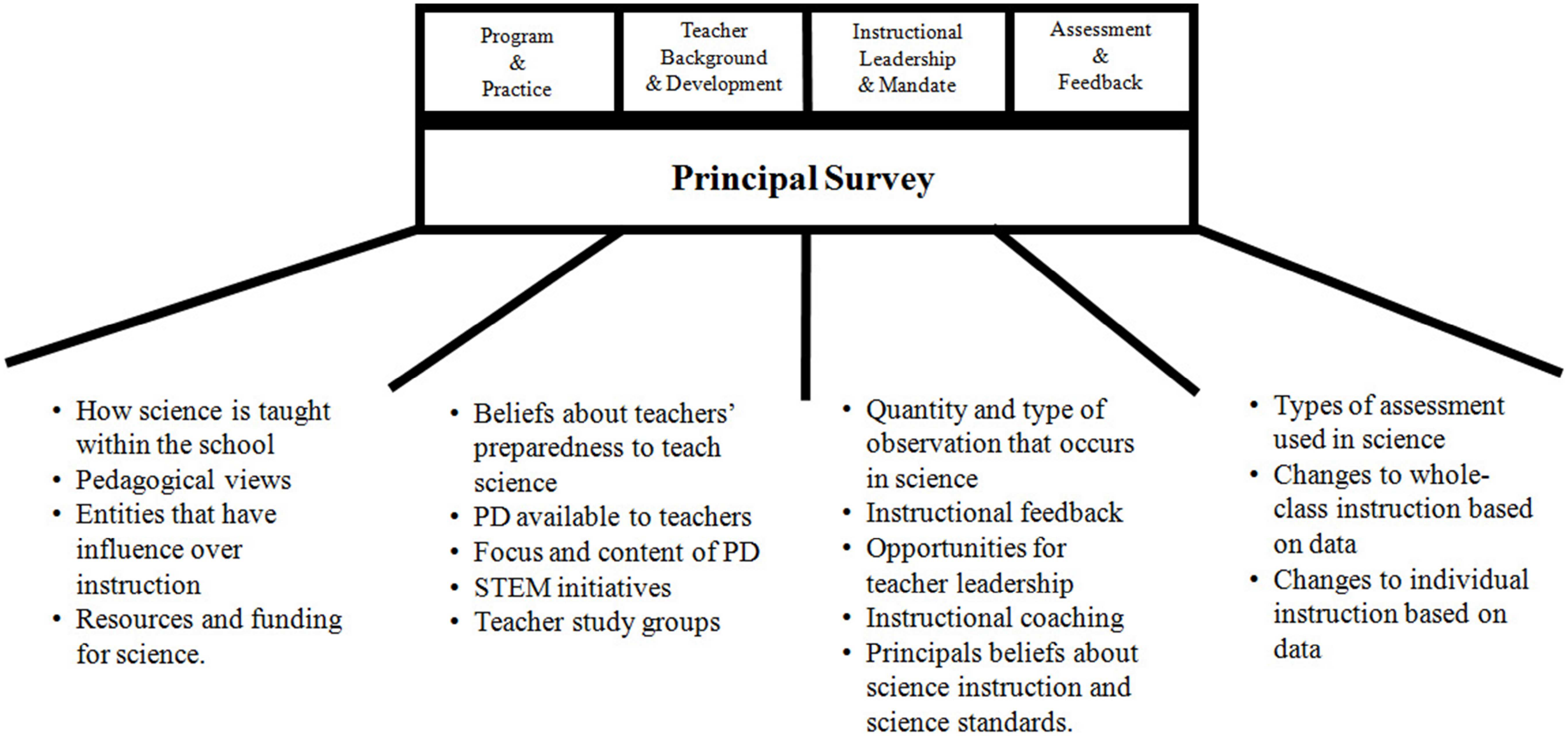


Figure 3. Focus of Principal Survey Items

The Horizon Research (2012b) *Science Program Survey* was primarily used to create the School Programs and Practices, and Professional Development components of the principal survey used in this study. Using factor analysis, Horizon Research combined questions within important constructs in science education and tested whether the items targeted the same underlying constructs, resulting in Cronbach's alpha reliability coefficients for these question composites (Banilower et al., 2013). Composite scores provide a way to report summative responses for large amounts of data and provide a greater reliability than that of individual survey item (Banilower et al., 2013). Horizon Research identified six composites in their *Science Program Survey.* Three of these composites are presented within the principal survey used in this study (Banilower et al., 2013). These constructs and their respective Cronbach's alpha reliability coefficients are presented in Table 5. Cronbach's alpha reliability coefficients found on *Science Program Survey* (Horizon Research, 2012b) for each of these composites ranges from 0.65 – 0.78, indicating a moderate to strong reliability for each composite (Banilower et al., 2013). I calculated Cronbach's alpha reliability coefficients for each of these same question composites for this study and found slightly better results, with alphas that ranged between 0.79 – 0.82. I used these composites to make comparisons between Idaho's high science achieving low and high-SES schools.

Table 5. Composite Questions Used on the Principal Survey Developed by Horizon Research (2012c)

Variable	Question Composites	Alpha (Horizon Research, 2012c)	Alpha
Instructional Leadership & Mandate	Supportive Context for Science Instruction	0.78	0.79
Instructional Leadership & Mandate	Extent to Which a Lack of Material and Supplies is Problematic	0.76	0.81
Instructional Leadership & Mandate	Extent to Which a Lack of Time is Problematic	0.65	0.82

To calculate the composite values, I used the method outlined by Banilower et al. (2013). This process required that I first recode the responses to set the Likert scales to zero. For example, a Likert scales of 1-4 was converted to 0-3 and a Likert scale of 1-5 was converted to 0-4. This recoding was completed to assure that 50 became the true mid-point of the data when placed on a 100-point scale. The composite data was placed on a 100-point scale by computing the maximum sum of responses for a series of items and dividing by 100; for example, a 5-item composite where each item was on a scale of 0-4 would have a denominator of 0.20. This number became the denominator in the composite calculation. I calculated the composite by calculating the sum of the actual responses to the items associated with that composite, and dividing by the prepared denominator. I completed this process for each respondent. Since my data was non-parametric, I reported the median scores for each composite.

I selected additional survey items from the following published surveys: *2012 National Survey of Science and Mathematics Education: School Coordinator*

Questionnaire (Horizon Research, 2012a); *Instructional Leadership Action/Behavior Questionnaire* (Lanier, 2008; Lanier et al., 2009); and *Data-driven Decision Making Questionnaire* (Pritz & Kelley, 2009). Horizon Research's (2012a) *2012 National Survey of Science and Mathematics Education: School Coordinator Questionnaire* was administered as part of the 2012 National Survey of Science to collect initial background information from each of the participating schools. I used this survey to construct background questions in this study's principal survey. *Instructional Leadership Action/Behavior Questionnaire* was a survey instrument developed for a dissertation aimed at identifying the role of instructional leadership in influencing elementary science programs and was later presented at the Annual Meeting of the National Association of Research in Science Teaching (Lanier, 2008; Lanier et al., 2009). The *Instructional Leadership Action/Behavior Questionnaire* was used to help develop the Instructional Leadership and Mandate section of the principal survey. The *Data-driven Decision Making Questionnaire* (Pritz & Kelley, 2009) was used to help develop the Assessment section of the Principal survey. *The Data-driven Decision Making Questionnaire* was developed to identify if teachers and principals understand how to use data effectively and was funded by the U.S. Department of Education. The questions developed from these surveys provide both descriptive and inferential statistics to compare Idaho's high science achieving low and high-SES schools to one another.

The Classroom Level: Teacher Survey

At the classroom level, teachers were surveyed on items pertaining to each of the four key elements of elementary science reform: Program and Practice, Teacher Background and Development, Instructional Leadership and Mandate, and Assessment and Feedback (see Figure 3). The teacher survey tool was created primarily from the *2012 National Survey of Science and Mathematics - Science Teacher Questionnaire* (Horizon Research, 2012c). The Horizon Research (2012c) teacher questionnaire explicitly targets teachers' knowledge of and control of elementary science education. This tool lends itself to easily be adapted as an Internet-based tool. The teacher survey (Appendix C) is composed of 11 background questions, and 57 questions on the key elements, and 2 conclusion questions. The survey has an additional five questions on background and an open-response conclusion question. The survey was composed of binary yes/no items, five-point Likert items, and fill-in items (see Appendix C). The teacher survey took approximately 30 minutes to complete, however many participants completed the survey over several sessions.

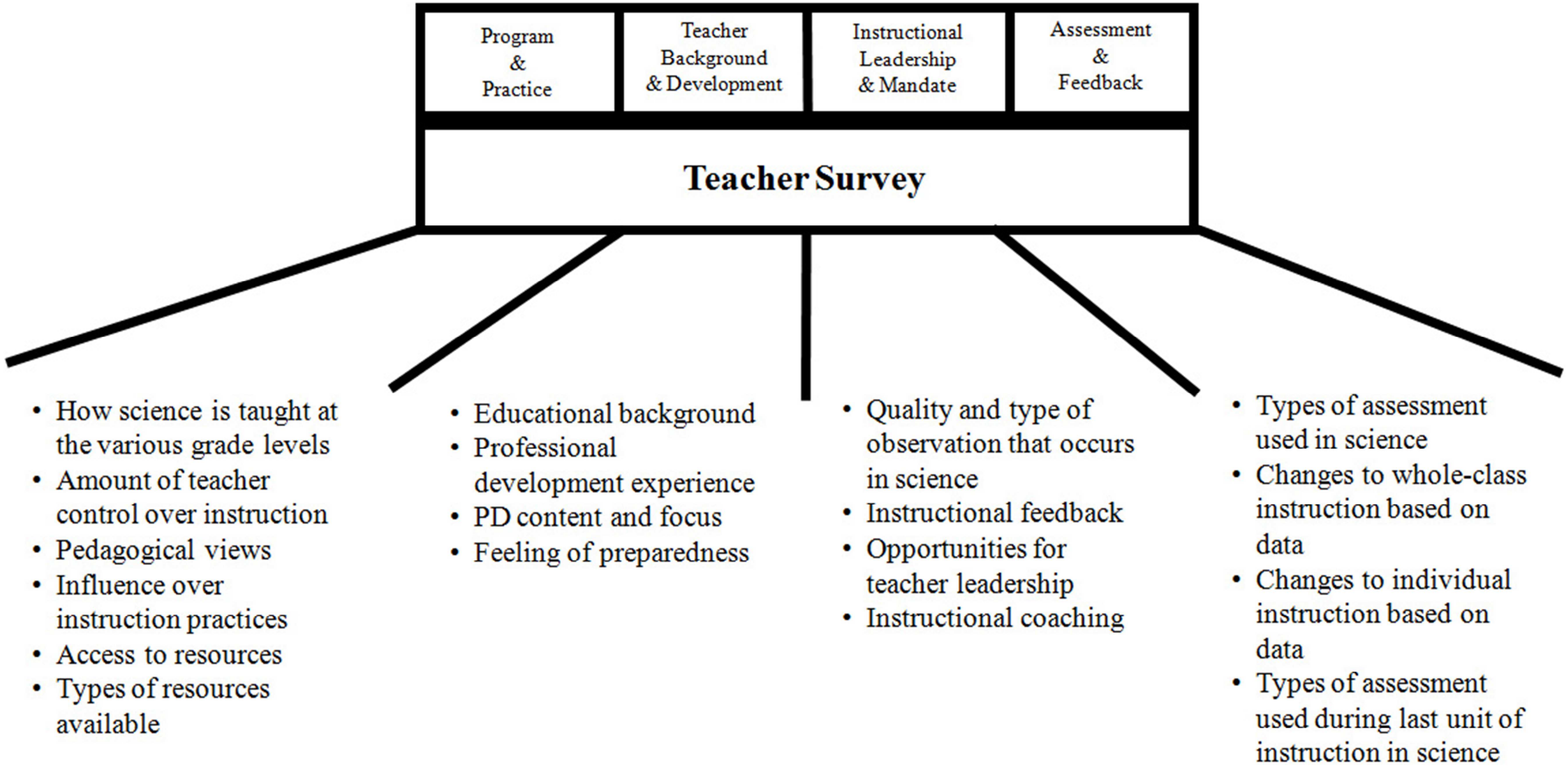


Figure 4. Focus of Teacher Survey Items

The Horizon Research (2012c) *Science Teacher Questionnaire* was used to develop the school Programs and Practices, Teacher Background and Development, and Assessment and Feedback sections of the teacher survey. Using factor analysis, Horizon Research combined questions within important constructs in science education and tested whether the items targeted the same underlying constructs, resulting in Cronbach's alpha reliability coefficients for these question composites (Banilower et al., 2013). Horizon Research (2012c) calculated Cronbach's alpha reliability coefficients for 21 composites on their *Science Teacher Questionnaire*. Presented in Table A5 are the composites I used in the teacher survey, their respective Cronbach's alpha reliability coefficient reported for the *Science Teacher Questionnaire*, and the Cronbach's alpha reliability coefficient calculated from this study (Banilower et al., 2013).

Cronbach's alpha reliability coefficients for the Horizon Research (2012c) *Science Teacher Questionnaire* range from 0.70 to 0.92 indicating moderate to strong reliability for each item on the survey (Banilower et al., 2013). Using the same composite, I calculated Cronbach's alpha reliability coefficients for this study that ranged from 0.50 – 0.98. I had two composites that fell into the poor reliability category; these included: Instructional Technology Composite (0.50) and Pedagogical Control (0.75).

The various composites were used to compare Idaho's high science achieving low high-SES schools to one another. To calculate the composite values, I used the method outlined by Banilower et al. (2013), described in the "School Level: Principal Survey" section of this study. The remaining data acquired from the teacher survey provided both descriptive and inferential statistic analysis for the following key elements: Programs and Practices, Teacher Background and Development, and Assessment and Feedback.

The Instructional Leadership section of the teacher survey was influenced primarily by the *Principal Leadership Survey* created by Louis et al. (2010). Two of five constructs that are identified in the *Principal Leadership Survey* were used to develop the Instruction Leadership section of the teacher survey. Further information about the composites developed from these constructions are identified in Table 6 along with the Cronbach's alpha reliability coefficients reported by Louis et al. (2010) and the Cronbach's alpha reliability coefficients calculated for this study. These composite scores for each of these composites provided the opportunity to use inferential statistics to compare Idaho's high science achieving low-SES and high-SES schools to one another.

Table 6. Teacher Survey Composites for Instructional Leadership and Mandate

Variable	Question Composite	Alpha (Louis et al, 2010)	Alpha
Instructional Leadership & Mandate	Shared Leadership	0.78	0.88
Instructional Leadership & Mandate	Instructional Leadership	0.82	0.71

Other published surveys that influenced the development of the teacher survey include: *2012 National Survey of Science and Mathematics Education: School Coordinator Questionnaire* (Horizon Research, 2012a); *Instructional Leadership Action/Behavior Questionnaire* (Lanier, 2008; Lanier et al., 2009); and *Data-driven Decision Making Questionnaire* (Pritz & Kelley, 2009). The questions developed from these surveys provide descriptive statistics to compare Idaho's high science achieving low and high-SES schools to one another for the following key elements: Assessment and Feedback, and Leadership and Mandate.

Methodology

Participant schools for the study were identified using science ISAT data for the past three years (ISDE, 2011a, 2012a, 2013c) to establish consistency in results. Criteria for participation in this study included the following:

- High achievement, scale scores that fit into either *Advanced* (216+) or within the top third of *Proficient* (212-215). See Table 4 for fifth grade science ISAT scale score bands (ISDE, 2007b).
- A minimum of 30% of fifth grade students performing within the *Advanced* category on the science ISAT, to prevent a few super achievers from skewing the results.
- Fifth grade classes of 25% or less FRL qualification (high SES) and fifth grade classes of 40% or greater FRL qualification (low SES). Schools were also checked to ensure that the school-level FRL status met these criteria.
- Consistent scale scores over three consecutive years of science ISAT testing at the fifth grade level, looking at 2011, 2012, and 2013 science ISAT results (ISDE, 2011a, 2012a, 2013a).
- A minimum enrollment of 50 students at the fifth grade level, ensuring multiple teachers and reducing the statistical effects of small population sizes on percent FRL, and the effect of individual student scale scores on the average scale score.

After I received Boise State University Institutional Review Board Human Subjects (IRB) approval on November 7, 2013, I submitted a proposal to conduct research in each of the 19 Idaho school districts in which the identified schools reside. I received approval from 17 of these school districts. I began administering the principal surveys. The survey format that I chose was an electronic survey administered through Qualtrics. I chose an electronic survey format because they are low cost and provide a high level of fidelity to implementation.

The challenge electronic surveys created was in attaining high response rates. It is well documented that people who receive Internet-based surveys are more likely to complete them if they know the person they are receiving the survey from and they feel a connection to the purpose of the survey (Fowler, 2009; Perkins, 2011). For this reason, I made telephone contact with the each of the principals from the identified schools within each participant district. I followed a telephone script (see Appendix B) that included an introduction and a short explanation of the study. I answered questions and asked the principal to participate in the study. If the principal agreed to participate, I sent the principal an e-mail invitation to participate in the study by completing the principal survey.

The survey questions were designed to have the following qualities: use of short items, use of simple direct items, use of all single-faceted items, avoidance of biased wording, and use of meaningful, mutually exclusive descriptive scales (Anderson & Kanuka, 2003; Fowler, 2009). Another factor that I addressed in survey development was the use of follow-up reminders. Research by Klofstad, Boulianne, and Basson (2008), found that when participants are told that they will receive a reminder to complete the survey, it provides press, making them more likely to complete the survey early. Additional research by Joinson, Woodley, and Reips (2007) found that when survey invitations were addressed to the participant and either provided a link to a secure survey site or provided a login and password to a secure survey site, they were more likely to take the survey and less likely to leave items blank. Reminders were sent to principals once per week.

I collected descriptive background data (ethnicity, gender, and age) from both the principals and the teachers. I used these data to ensure that the principal and teacher samples were representative Idaho samples. All collected data containing personal identifiers were stored on the Boise State University (BSU) database associated with Qualtrics or on a password protected thumb drive. During the analysis phase, data were stored in SPSS and Excel files on a password protected thumb drive.

Since my sample size was limited, indirectly, by the small size of Idaho, it was important to get a high response rate from both the principal and teacher surveys. For this reason, it was important to: develop trust, reduce the risk to participants, and ensure that the completion of the survey was not burdensome. Trust was developed initially with the districts and principals through introductory phone conversations and the connection to Boise State University. Going through both IRB and the districts’ research committees’ processes reduced the potential risk to participants. Development of both the principal and teacher surveys were accomplished by using already tested survey items and by trialing the surveys prior to their use (Perkins, 2011).

I implemented the principal and teacher surveys using similar processes. However, because of the larger number of teachers selected to take the survey, 80, I did not attempt to make personal contact with each teacher. Principals were asked to select and provide names of third, fourth, and fifth grade teachers that they would like to participate in the teacher survey sample. Principals were also asked to talk to their selected teachers about the study, so that when they received an invitation to participate, they would already be familiar with the study. The rest of the procedures were the same as the principal survey.

Teachers and principals, both, received an e-mail invitation to participate in the survey (see Appendix B). I obtained informed consent from participants at the start of each survey. If participants choose to provide informed consent, they were directed to the survey. If the participants elected not to provide consent, they were redirected to the end of the survey and no data were collected. For principals who chose to participate in the survey, the survey took approximately 15 minutes to complete. I followed the initial letter and survey link with a weekly reminder letter and survey link (see Appendix B). The survey began on December 6, 2013 and concluded on January 6, 2014. For teachers that choose to participate in the survey, the survey took approximately 30 minutes to complete. I followed the initial letter and survey link with a weekly reminder letter and survey link. The survey began on March 13, 2014. I sent weekly e-mail reminders until May 6, 2014, when I sent the last reminder. I closed the teacher survey on May 9, 2014.

Analysis

Principal Survey and Teacher Survey

The principal and teacher surveys (Appendix C) contained binary response items, five-point Likert scale items, and open-response items. The quantitative data obtained from these surveys were analyzed using descriptive analysis and between-measures analysis. The between-measures analysis evaluated the differences in implementation level of the four key elements to elementary science reform between low and high-SES, high science achieving Idaho elementary schools. I used the Shapiro-Wilk Test of Normality to determine if my data were normally distributed, thus determining if a parametric or a non-parametric test should be used to analyze the data. The Shapiro-Wilk test can be used on small sample sizes (<50), but is also appropriate for samples up to 2000. The null hypothesis for the Shapiro-Wilk Test of Normality assumes normal distribution of data, so if the p-value is below the critical value of 0.05, then the null hypothesis is rejected and the population is found to have a non-normal distribution (Razali & Wah, 2011; Shapiro & Wilk, 1965). The results of the Shapiro-Wilk tests indicated that the majority of my data were non-parametric in nature, so I used medians as my measure of central tendency, and Pearson’s Chi-square tests and Mann-Whitney U tests to compare the low and high-SES schools’ principal/teacher survey results.

Between-Measures Analysis

I analyzed the binary response items using the Pearson’s Chi-square test to test for significant differences between the low and high-SES schools. The Pearson’s Chi-square test was chosen because it is a non-parametric test that tests for goodness of fit to theoretical distributions and as a test of independence to two variables (low and high

SES). Although the Pearson’s Chi-square test is based on random sampling, Chi-square test has been identified for use with some non-random sample methods (Michael, 2001). According to Tongco (2007), who wrote exclusively on the purposive sampling methodology, Chi-square test is an accepted method of purposive sampling analysis. Pearson’s Chi-square test requires the presence of independent observations. Independent observations are present when the response of one person has no influence on the response of another person’s response. Internet-based survey sampling lends itself to independent observations. Since the selected principal participants are from across the state of Idaho, it is unlikely that one participant had any influence on another participant’s response. Pearson’s Chi-square test works best with large samples and large expected frequencies (Michael, 2001). When samples are large and the expected frequencies are greater than five, the sampling distribution is closer to predicting Pearson’s Chi-square test distributions. When expected frequencies are too small, the sample size is probably too small, and the sampling distribution becomes too deviant from a Pearson’s Chi-square test distribution to be useful. Fisher developed a method for computing the exact probability of the Pearson’s Chi-square test statistic that is accurate when sample sizes are small. This method is called the Fisher’s exact test (Field, 2013; Fisher, 1922). I used and reported the Fisher’s exact test to verify reliable statistical conclusions. The final assumption of a Pearson’s Chi-square test is that the null hypothesis states that there is no relationship between classifications. The alternate hypothesis states that a relationship or dependency exists. In addition, frequency distribution graphs and cross-tabular data tables were used to analyze responses for each of the binary response questions. I used the Pearson’s Chi-Squared test to run initial analyses. When a significant difference was found, I looked at Fisher's exact test to verify significance.

The five-point Likert items can arguably be considered scaled ordinal data. However, because of the nature of the Likert scale, I analyzed these data as scaled numerical data using the Mann-Whitney U test. The progressive incremental scale ranges, for example: from (1) Unimportant to (5) Very Important. The data provided by the open-ended questions within the survey were also analyzed using the Mann-Whitney U test. The Mann-Whitney U test null hypothesis states that the two groups come from the same population. My study meets the following Mann-Whitney U test assumptions: independent observations, there is no relationship between the observations in each group or between the groups themselves; the dependent variable is measured at the ordinal, interval, or ratio level; and the independent variable consists of two categorical groups from one population (low and high SES). The data can have a non-normal distribution, but since the two groups come from one population, the Mann-Whintey U test assumes equal variances. To ensure equal variance, I ran a proxy homogeneity of variance test for equal variance. The test I chose was a non-parametric Levene's test. The null hypothesis for the Leven's test assumes the data had equal variance (Nordstokke, Zumbo, Cairns, & Saklofske, 2011).

The teacher and principal open-ended questions were analyzed to contribute further insight into survey questions. They were analyzed using qualitative methods. I coded the qualitative data initially using the four reform-based evidence categories, but as I found other commonalities in the data, I added these additional descriptors. The process of coding the data required several reads to accomplish. I looked for patterns in the data to emerge as I read through the principal and teacher responses and thought about them in terms of low and high SES, as well as classroom view verses school-wide view (Bogdan & Biklen, 2007; Foss & Waters, 2007; Ryan & Bernard, 2003).

Matching School Data

Each participant was assigned a unique random number during the study; these numbers were linked to their schools in *Qualtrics*. This provided me the opportunity to match data from the principal survey and teacher survey (see Table A6). The purpose of this matching was to increase the validity of the data by providing a verification check of the self-report data.

Threats to Validity

Threats to validity in this study included the use of self-report survey data, which relies on the assumption that principals and teachers are providing true, accurate, and thoughtful answers to the self-report survey questions. To combat this, I performed a validity check by making comparisons between the teacher and principal survey data.

Instruments used to survey principals and teachers about science education, assessment, and leadership that were appropriate to this study were limited and some of them did not contain Cronbach's alpha reliability coefficients associated with them. However, the composite of questions that I was able to use with Cronbach's alpha reliability coefficients had strong to moderate reliability. I also trialed the surveys prior to using them with participants, and made adjustments based on feedback from professionals.

I made every effort to provide the largest sample sizes available, reaching 64% of my teacher sample and 66% of my principal sample. Despite strong efforts to achieve the highest sample size, the limited sample size does pose a threat to my validity. Additional threats to validity came from using data analysis methods. I interpreted ordinal data as scale data, using the Mann-Whitney U test.

Ethical Procedures

Personal identifiers were collected in this study for the purpose of ensuring a representative sample. All data that were connected to personal identifiers were assigned a randomized code unique to each participant and was stored on the BSU database associated with Qualtrics or on a password-protected thumb drive. This included both survey data and observation protocol data. During the analysis phase, data were stored in SPSS and Excel files on a password-protected thumb drive. All participating individuals, schools, and districts participating in the study will have their identities masked in any published or unpublished report of findings from this study to ensure confidentiality of the participants. No data were collected from students or parents. This study only involved the collection of data from participant principals and teachers. This study received IRB approval, protocol number: 170-SB13-103 (Appendix D). Participating school districts will receive a copy of my findings in the form of the completed dissertation.

Summary

This study set out to examine the four key elements of elementary science education reform and their implementation level within high science achieving elementary schools in Idaho. This study uses the perspective of the school and classroom level to better understand the similarities and differences in the implementation level of these elements in low and high-SES schools. This study has two phases. Phase one uses a survey to evaluate the school level through the perspective of principals. Phase two uses a survey to evaluate the school level through the perspective of teachers. The data collected across both phases were matched to identify common influences present in both the school and classroom.

CHAPTER FOUR: RESEARCH FINDINGS

Introduction

The purpose of this study was to discover if the four key elements of elementary science education reform are present in high science achieving elementary schools within the state of Idaho. The four key elements to elementary science reform include: programs and practices, assessment and feedback, instructional leadership and mandate, and professional development (Inverness Research Associates, 2007).

This study sets out to answer the following questions:

Question 1: In Idaho, are all of the four key elements present in all of the high science achieving elementary schools?

Hypothesis 1: Based on three years of science ISAT results, the identified Idaho schools have consistently developed high achievers in science (ISDE, 2011a, 2012a, 2013a). As a state, Idaho has scored above the national average on the last National Assessment of Educational Progress (NAEP) test given in the elementary grades (NCES, 2011). The NAEP test is a rigorous test that tests beyond rote knowledge, making it reasonable to believe that evidence will be present in all of the highest science achieving schools in the state that indicates they are engaged in delivering all four key elements considered important to achieving success in elementary science.

Question 2: In Idaho, high science achievement can be found in both low and high socioeconomic status elementary schools. Does the evidence indicate a difference between the low and high SES schools' implementation of the key elements to elementary science reform in Idaho high science achieving schools?

Hypothesis 2: Based on the different pressures created by socioeconomic status in low and high-SES schools, the ability to implement each of the key elements will be different in the high science achieving, high and low-SES schools.

I attempted to answer these questions and test these hypotheses through both the perspective of the principal, giving insight into school-level factors that are contributing to the success of Idaho elementary schools in science, and through the teacher, providing insight into classroom level factors.

Data Collection

Forty elementary schools in the state of Idaho met the purposive sampling procedures described in Chapter Two. From this sample, 23 principals chose to participate in the study (58%). The participant principals provided the names of 80 teachers in third through fifth grades. Of these 80 teachers, 51 teachers chose to participate (64%).

The 23 participant schools have a three-year mean scale score on the science ISAT of 214, which would be considered a high *Proficient* rating (216 would receive an *Advanced* rating). As can be seen in Table 7, the three-year mean scores for both low and high-SES schools in mathematics and reading on the ISAT are at the *Advanced* rating level. The high-SES schools' three-year mean for language was at the *Advanced* level, while the low-SES schools received a high *Proficient* rating, just missing the cut off for *Advanced*. These results provide further evidence that language, reading, and mathematics were not confounding variables in the study, as all the schools scored similarly across all subject areas. A total of 34% of fifth grade students who qualified for FRL were represented in the total mean scale scores. This can be further broken down into 45% of the low-SES sample qualifying for FRL and 15% of the high-SES sample qualifying for FRL.

Table 7. Three Year Mean for Participant Schools' Fifth Grade Science ISAT Scale Scores

	Three-year Scale Score Mean for Sample		
Fifth Grade ISAT	Total (N = 23)	Low-SES (n = 16)	High-SES (n = 7)
Science	214	214	215
Mathematics	225	225	226
Reading	222	221	222
Language	221	221	222

The participating schools were composed of 16 traditional neighborhood schools, five district schools that have been identified as 'schools of choice,' 'magnet,' or 'focus schools,' and two charter schools. The structure of the schools varied, as seen in Table 8. The term 'elementary school' is used in this study to encompass all schools that include the primary target grade: fifth grade.

Table 8. Participant School Grade Structures by Percent

	Schools		
Grade	Sample (N=23)	Low-SES (n=16)	High-SES (n=7)
PreK/K–5 or K–6	70%	50%	71%
K–8	4%	0%	14%
K–12	9%	25%	14%
Middle Grades (3–5, 4–5, 4–6, or 5–6)	17%	25%	0%

Schools were invited to participate in all six regions of Idaho. Participant schools are located in five out of six of Idaho's regions (see Figure 4). Schools can be further defined as rural or non-rural districts. The state of Idaho has defined rural districts as either having fewer than 20 enrolled students per square mile within the school district boundaries or as a county in which the school district is located in an area with fewer than 25,000 residents, based on the most recent United States census. The participant sample represented nine rural school districts encompassing 9 participant schools (39%) and 5 non-rural school districts encompassing 14 participant schools (61%) (ISDE, 2013d).

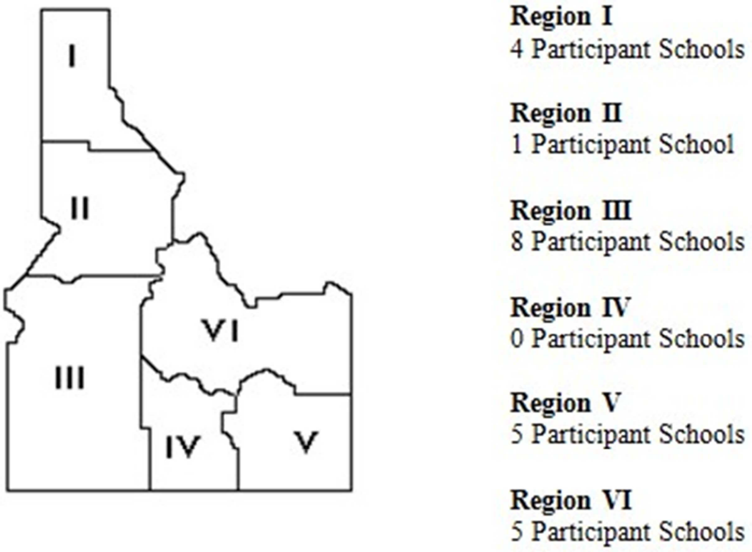


Figure 5. Participant School Dispersal Map

Participant Description

Principal Participant Description

The participant principals represent 15 low-SES schools and 8 high-SES schools. The low-SES schools range from 41 – 66% FRL school wide during the 2012-2013 school year. The high-SES schools range from 8% to 25% FRL school wide during the 2012-13 school year.

The demographics of the principal participant sample are as follows: 100% Caucasian; 48% Male and 52% Female; and mean age of 49. The principals who participated had a mean of 10 years experience as a principal, with a range of 0 to 20 years. Additionally, the principals had a mean of 4.5 years experience as principals in their current schools, with a range of 0-16 years. Principals' median years of prior teaching experience were 12 years, with a range of 0 to 31 years. The majority of this teaching experience comes from work in grades K-8, with only 17% of the principals with teaching experience exclusively at grades 9-10. Five principals reported that their 6-10 years teaching experience was in a STEM field. Four of these five had science teaching experience. See Table A7 for a complete breakdown of principal demographics. Overall, the Idaho participant sample had similar demographics to what is seen statewide (see Table A7).

According to the data presented by Snyder and Dillow (2012) from the National Center for Education Statistics, the demographics found in these Idaho schools are similar to the national mean. The national mean age for principals is 50 years old, with less than 12% of new principals 40 years or younger. The percentage of female principals is currently 44% of the workforce. In the United States, only 18% of public school principals were considered racial/ethnic minorities. The state of Idaho has a lower percentage than the national average of racial/ethnic diversity, so it was not surprising that 100% of the principals were Caucasian. Nationally, 99% of new principals are former teachers, with a mean of 14 years of classroom experience. This was consistent with what I found in the Idaho participants, with a mean of 13 years of experience, and 95% of the principals having prior teaching experience. The one principal that did not fall into this category had prior experience as a school counselor. The national trend also indicated more mobility, which was consistent with the principals' mean time in their current position being 5 years.

Teacher Participant Description

The participant teachers were from 20 of the 23 participant schools, 13 low-SES schools and 7 high-SES schools. Fourteen of the participant teachers were from high-SES schools (27%), and 37 of the participant teachers were from low-SES schools (73%). Teacher participants have teaching assignments in Grade 3 – 5. The breakdown of grade-level teaching assignments by the schools' SES status are presented in Table 9.

Table 9. Percent of Participant Teachers Assigned to Various Grade Levels

Grade	Teachers		
	Total (N = 51)	High-SES (n = 14)	Low-SES (n = 37)
Multi-grade Science Specialist	4%	14%	0%
Fifth Grade	37%	57%	78%
Fourth Grade	73%	14%	11%
Third Grade	12%	14%	11%

In Table 10, the teaching assignments are further broken down by their science teaching assignment. It is interesting to note that only 4% of the participant elementary schools had multi-grade science specialists, each of which were high-SES schools. Another interesting point was that 8% of the principal recommended, teacher participant sample reported that they did not teach science. Teachers reporting that they *did not teach science* were redirected to the end of the survey. Non-science teaching participants did not contribute data to the study following the basic demographic questions.

Table 10. Percent of Participant Teachers Assigned to Various Science Teaching Assignments

	Teachers		
	Total (N=51)	Low-SES (n=37)	High-SES (n=14)
K-5			
Multi-subject classroom teacher	75%	78%	64%
Science teacher for grade-level team	14%	16%	7%
Multi-subject classroom teacher that does not teach science	8%	5%	14%
K-8			
Multi-grade science specialist	4%	0%	14%

The general demographics for the teacher participant sample are as follows: 100% Caucasian; 18% Male and 82% Female; and mean age of 43. The teachers who participated had a mean of 13 years experience teaching, with a range of 1 to 34 years. Additionally, the teachers had a mean of 12 years experience as teachers within their current district, and 8 years within their current school. The teachers that indicated they teach science as part of the elementary curriculum had a mean of 9 years teaching science as part of the curriculum, and the teachers that indicated they were dedicated science teachers had a mean of 8 years teaching science. Table A8 provides a complete presentation of the teacher demographics.

Survey Implementation

The survey implementation went smoothly. Initial distribution of the survey identified an erratum in one of the question items on the principal survey. The first principal participant to take the survey contacted me, and I was able to close the survey, fix the miscue, and resend the survey links within a 20-minute time frame. This issue did not seem to affect participation, as those that tried to enter the survey during this time period accessed and completed the survey later. Initial contact via the telephone seemed to increase response rates. Principals with whom I only left messages did not have as high a response rate as those that I was able to speak with and introduce the study and myself. Four of the 23 participants, or 17%, who completed the principal survey received only a voice message. The remaining 19, or 83%, received direct contact with me via the telephone. After the first weekly reminder, additional reminders increased the response rate minimally, resulting in one or two responses each week. Another factor that seemed to increase the response rate was district-level contact with the principals about the survey. It appeared that in districts where the principals already knew about the survey, prior to my contact, there was increased interest in completing the survey.

The teacher survey went smoothly, as well. The most challenging part of implementing the teacher survey was collecting the names of the teachers from the principals. As a result, I began the survey prior to having all of the participant names. Some teachers received more reminders to complete the survey than others, depending on when I received their name to participate. The participant teachers received a reminder to complete the survey once per week, and every teacher had, at minimum, five weeks to complete the survey.

Results

The results section has been organized by the four key elements: Programs and Practices, Teacher Background and Development, Instructional Leadership and Mandate, and Assessment and Feedback. Data related to each of the two study questions from both the teacher and principal surveys were handled within each of these four major sections, first discussing the population as a whole, then discussing the sub-populations of low and high SES.

Programs and Practices

Time for Science Instruction

When asked to describe the frequency at which science was taught in their schools, the majority of teachers, 76%, indicated that science was taught every week (see Figure 5). However, when asked how many weeks per year were spent on mathematics, science, social studies, and reading/English language arts, teachers indicated that they did not teach science every week of the year.

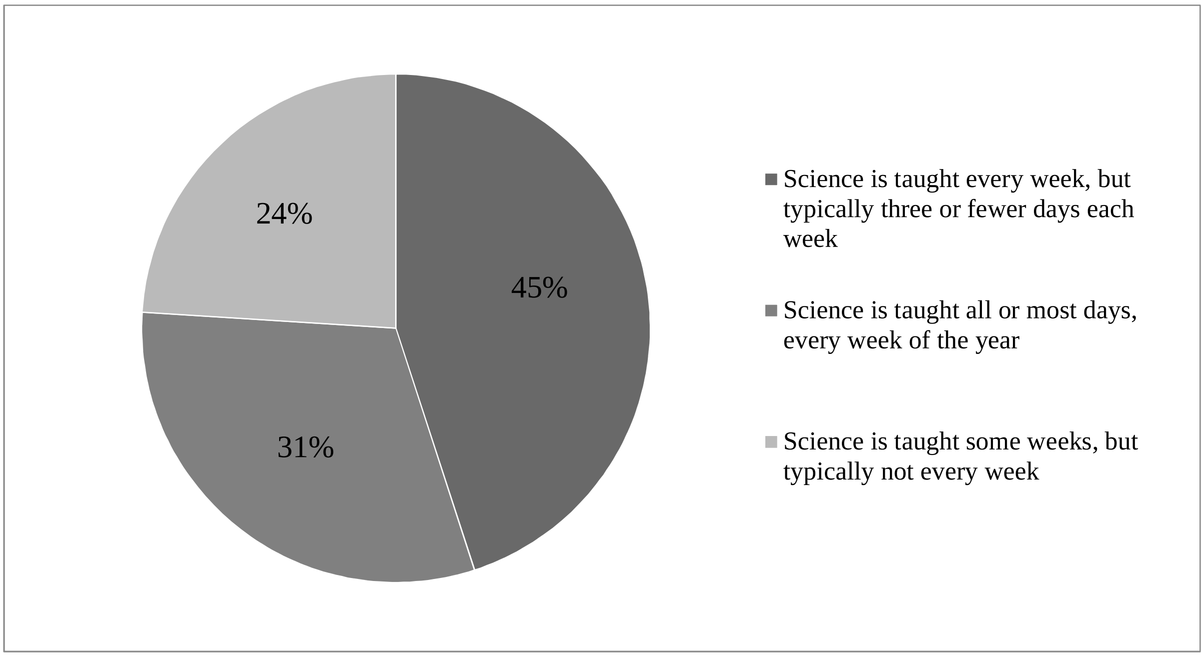


Figure 6. Percent of Teachers Reporting Frequency of Science Teaching

Teachers were asked about how much time they devote to science teaching. The median time reported by the teachers that they spent on science added up to 4,320 minutes on science instruction (12% of instructional time), 16,200 minutes on reading/ ELA instruction (44% of instructional time), 12,600 minutes on mathematics instruction (34% of instructional time), and 3,800 minutes on social studies instruction (12% of instructional time) per year (see Figure 6). In high science achieving elementary schools, teachers reported spending nearly four times longer on reading and ELA instruction than they spent on science per year (see Table A10). I found no significant differences in these trends between low and high-SES schools (*p* > 0.05).

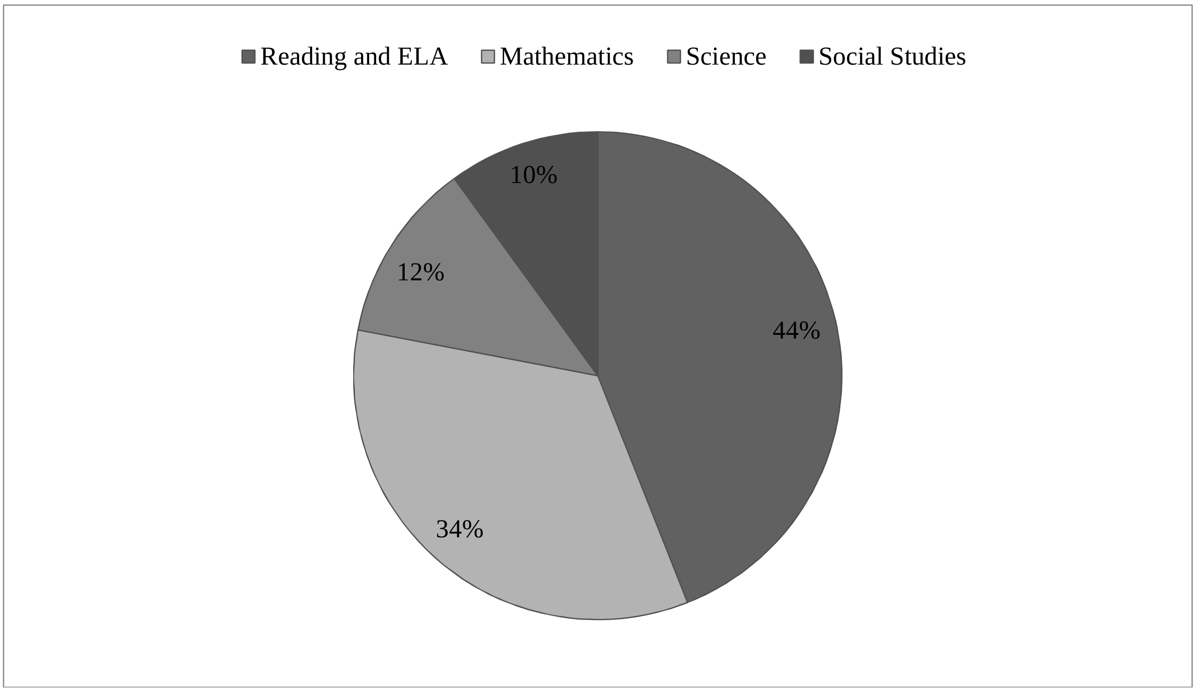
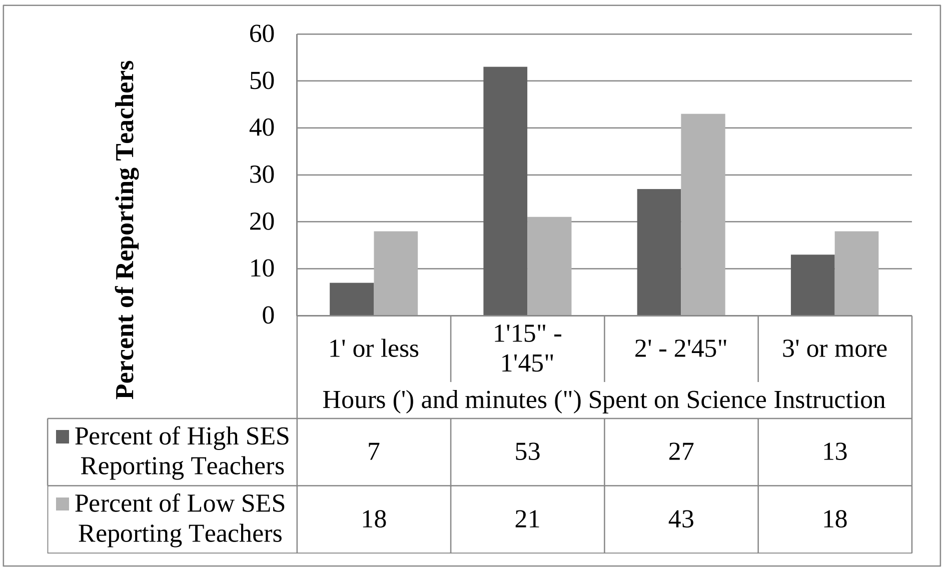


Figure 7. Teacher Reported Percent of Time Spent on Teaching Core Curriculum

When the time spent on science was averaged over a 36-week school year, I found that the Idaho high science achieving schools spent a median of 2 hours per week, as reported by 43 teacher responses (see Figure 9).

When I considered the time spent on science in the low and high-SES schools, averaged over a 36 week school year (see Figure 8), I found that sixty-one percent of the low-SES teacher responses fell into 2 or more hours per week, while 40% of the high-SES teachers responses fell into the same category. The majority of high-SES teacher responses (53%) fell into the one hour 15 minutes to one hour 45 minutes category.



	1' or less	1'15" - 1'45"	2' - 2'45"	3' or more
■ Percent of High SES Reporting Teachers	7	53	27	13
▨ Percent of Low SES Reporting Teachers	18	21	43	18

Figure 8 Time Spent per Week on Science Instruction Low and High-SES Schools, as Reported by Teachers

When principals were asked about time spent on science, they indicated that insufficient time to teach science was an important factor that needed to be addressed. I found no significant difference in the responses of low and high-SES principals on this line of questioning ($p > 0.05$).

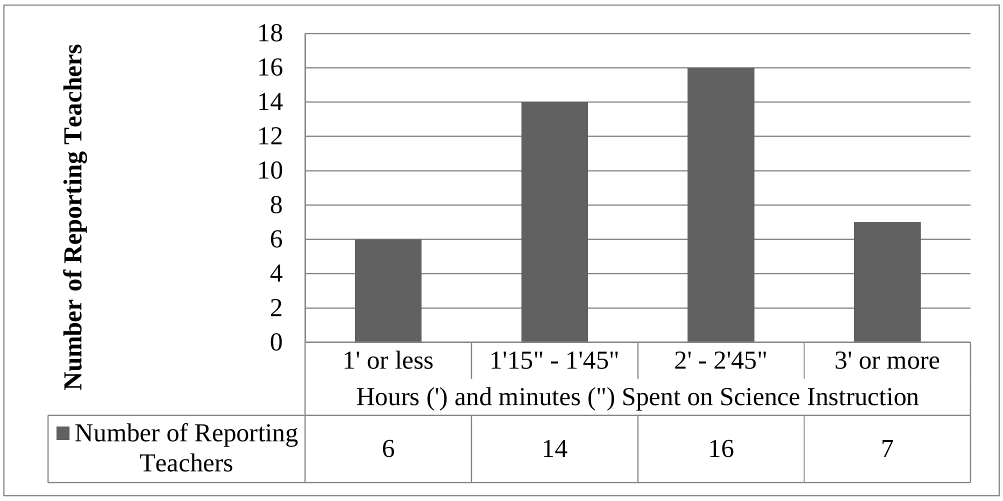


Figure 9 **Time Spent per Week on Science Instruction in Idaho High Science Achieving Schools, as Reported by Teachers**

A composite score was calculated for the extent to which a lack of time is problematic, and these data are displayed in Table 11.

Table 11. **Median Composite Score for the Extent to Which a Lack of Time Is Problematic**

Composite	Principals			Mann-Whitney U test, p-value
	Total (N=23)	Low-SES (n=15)	High-SES (n=8)	
Lack of Time is Problematic	67 (31, 83)	63 (19, 96)	67 (40, 77)	$U = 55$, $z = -0.07$, $p = 0.97$

Promoting Effective Science Instruction

Factors that teachers identified as important in promoting effective science instruction included: principal support; time for them to plan individually and with colleagues; time for professional development; student reading abilities; student motivation, interests, and effort in science; and the Idaho Content Standards. Factors such as: the Common Core State Standards; Next Generation Science Standards; district pacing guides; state science testing and accountability policies; textbook or module selection policies; community views on science; and parent expectations were seen as moderately important in promoting effective science instruction. Interestingly, only 6% of participant principals reported being knowledgeable of the Next Generation Science Standards. I found no significant difference between low and high-SES schools on these factors ($p > 0.05$). Principals saw lack of opportunities for science teachers to share ideas as a moderately important factor that needed to be addressed. I found no significant difference in the responses of low and high-SES principals on this line of questioning ($p > 0.05$).

Low and high-SES schools did demonstrate a difference in the importance of the district science curriculum framework ($U = 101$, $z = -2.07$, $p = 0.045$). Teachers in high-SES schools indicated that the district curriculum framework was important, and teachers in the low-SES schools viewed the district science curriculum framework as moderately important.

Teachers indicated that although they have *moderate control* over course goals, they have *strong control* over selecting their teaching techniques and determining the amount of homework they assign. I found a significant difference between low and high-SES school teachers' perceived control over textbook or module selection ($U = 281$, $z = 2.46$, $p = 0.02$), choosing criteria to grade student performance ($U = 290$, $z = 3.06$, $p = 0.01$), and section of content, topics, and skills to be taught ($U = 282$, $z = 2.42$, $p = 0.02$) (see Table 12).

Table 12. Median Ratings* for Teachers Perception of Control Over Pedagogy and Curriculum Content

	Teachers			
	Total (N=44) Median (IQR)	Low-SES (n=32) Median (IQR)	High-SES (n=12) Median (IQR)	Mann-Whitney U test, p-value
Determining course goals	3 (2, 5)	3 (2, 5)	3 (2, 5)	*U* = 213, *z* = 0.55, *p* = 0.59
Selecting textbooks/modules	2 (1, 3)	3 (1, 3)	1 (1, 2)	*U* = 281, *z* = 2.46, *p* = 0.02
Selection content, topics, and skills to be taught	3 (2, 5)	4 (2, 5)	2 (1, 4)	*U* = 282, *z* = 2.42, *p* = 0.02
Selecting teaching techniques	5 (5, 5)	5 (5, 5)	5 (4, 5)	*U* = 218, *z* = 0.94, *p* = 0.51
Determining the amount of homework to be assigned	5 (5,5)	5 (5, 5)	5 (4, 5)	*U* = 236, *z* = 1.73, *p* = 0.26
Choosing criteria for grading student performance	5 (4, 5)	5 (5, 5)	4 (3, 5)	*U* = 290, *z* = 3.06, *p* = 0.01

* (1) No control, (2) Little control, (3) Moderate control, (4) Considerable control, (5) Strong control.

Teacher control over curriculum and teaching pedagogy was further assessed using questions from the questions in Table 12 to create composites on curriculum control and pedagogical control. These composites revealed significant differences between the low and high-SES school teacher responses to these lines of questioning. High-SES teachers felt that they had less control over both curriculum and pedagogical control of their instruction than the low-SES teachers (see Table 13).

Table 13. Teacher Programs and Practices Median Composite Scores

Composite	Teachers Total (N=44) Median (IQR)	 Low-SES (n = 32) Median (IQR)	 High-SES (n=12) Median (IQR)	Mann-Whitney U test, p-value
Curriculum Control	45 (17, 73)	50 (33, 75)	21 (8, 54)	U = 267, z = 1.99, p = 0.049
Pedagogical Control	100 (83, 100)	100 (92, 100)	79 (75, 98)	U = 295, z = 3.02, p = 0.006

Science Teaching Practices

The teachers reported that they completed the following activities *during all or almost all* of their science lessons: at the start of a lesson they provided students with the purpose of the lesson, engaged the whole class in discussions in all or most science classes, and they provided opportunities for students to share their thinking and reasoning. Science reform-based activities that occurred *often, or once or twice per week*, included: having students work in small groups; requiring students to supply evidence with their answers; and covering ideas in-depth, even if that meant covering fewer topics. Reform activities that teachers from both low and high-SES schools reported *sometimes* implementing included engaging the class in project-based learning (PBL) activities and having students represent or analyze data using tables, charts, or graphs (see Table A12). Reform-oriented practices that teachers from low and high-SES schools responded significantly different on included: doing hands-on/laboratory activities (U = 105, z = -2.32, p = 0.03) and having students write reflections (U = 97, z = -2.31, p = 0.03). Teachers from low-SES schools indicated that they only *sometimes* asked students to write reflections. Teachers from high-SES schools reported asking their students to write reflections *often*. Teachers from low-SES schools indicated that they only used hands-on or laboratory activities with their students *sometimes, or once or twice a month*. Teachers from high-SES schools reported that they implemented hands-on or laboratory activities with their students *often*. When principals were asked about the importance of students engaging in hands-on activities, both low and high-SES principals reported a median ranking of *very important* (see Table A13).

Non-reform-based instructional practices that teachers reported they engaged in *often* included: focusing on reading literacy skills, having students read from science textbooks or other related material, and providing hands-on activities primarily to reinforce a science idea that the students have already learned. Additionally, teachers reported *sometimes* explaining an idea to students before having them consider evidence that relates to the idea and providing students with definitions for new science vocabulary at the beginning of instruction. I found no additional significant differences between low and high-SES schools on these factors ($p > 0.05$) (see Table A12).

When teachers were asked about the importance of various science teaching practices, I found no significant difference between low and high-SES schools ($p > 0.05$). Teachers rated the following practices as *very important in promoting effective instruction*: understanding science, learning about real-life application of science, increasing students' interests in science, and preparing students for future study in science. Other items that they rated as *important in promoting effective instruction included*: learning science process skills and learning test taking skills and strategies. Memorizing science vocabulary or facts was seen as *moderately important in promoting effective instruction* (see Table 15).

Table 14. Teachers Use of Reform-Oriented Teaching Practices Median Composite Scores

Composite	Teachers			Mann-Whitney U test, p-value
	Total (N=42) Median (IQR)	Low-SES (n = 31) Median (IQR)	High-SES (n=11) Median (IQR)	
Use of Reform-Oriented Teaching Practices	67 (50, 79)	63 (50, 75)	79 (63, 88)	$U = 97$, $z =-2.11$, $p = 0.04$

I used questions focused on the frequency that teachers' implemented reform-based science teaching practices, found in Table A12, to calculate composite scores on the use of reform-based teaching practices. I found a significant difference between low and high-SES school teachers for the reform-based teaching practices ($U = 97$, $z = -2.11$, $p = 0.04$). High-SES school teachers had a median composite score of 79 (63, 88) and the low-SES school teachers had a median composite score of 67 (50, 79) out of 100, indicating that high-SES school teachers reported that they conducted reform-based teaching in their classroom more frequently than low-SES school teachers.

Table 15. Median Teachers Ratings* of Importance for Various Reform and Non-reform Science Teaching Practices

	Teachers			
	Total (N=44) Median (IQR)	Low-SES (n=32) Median (IQR)	High-SES (n=12) Median (IQR)	Mann Whitney U-test, p-value
Memorizing science vocabulary and/or facts	3 (3,4)	3 (3,4)	3 (2.25, 3.75))	$U = 228$, $z = 1.00$, $p = 0.354$
Understanding science	5 (4,5)	5 (4,5)	5 (5,5)	$U = 137.5$, $z = -1.66$, $p = 0.153$
Learning science process skills (for example: observing, measuring)	4 (4,5)	4 (4,5)	4.5 (4,5)	$U = 185.5$, $z = 33.55$, $p = 0.866$
Learning about real-life applications of science	5 (4,5)	5 (4,5)	5 (4,5)	$U = 173$, $z = -0.57$, $p = 0.630$
Increasing students' interests in science	5 (4,5)	5 (4,5)	5 (4.25,5)	$U = 168$, $z = -0.77$, $p = 0.541$
Preparing students for future study in science	5 (4,5)	5 (4,5)	4 (4.25,5)	$U = 135$, $z = -1.67$, $p = 0.138$
Learning test taking skills/strategies	4 (3,4)	4 (3,4)	3.5 (2.25,4)	$U = 224$, $z = 0.89$, $p = 0.412$

* (1) Inhibits effective instruction, (2) Of little importance in promoting effective instruction, (3) Moderately important in promoting effective instruction, (5) Important in promoting effective instruction, (5) Very important in promoting effective instruction.

Teachers' beliefs about the importance of implementing reform-oriented instructional objectives were further evaluated by calculating composite scores for reform-oriented questions found in Table 15; these scores are presented in Table 16.

Table 16. Teacher Beliefs about the Importance of Implementing Reform-Oriented Instruction Median Composite Scores

Question Composite	Teachers			Mann-Whitney U test, p-value
	Total (N=44) Median (IQR)	Low-SES (n = 32) Median (IQR)	High-SES (n=12) Median (IQR)	
Reform-Oriented Instructional Objectives	90 (80, 95)	90 (75, 95)	95 (86, 100)	$U = 107$, $z = -1.86$, $p = 0.07$

Principals were asked about the importance of various science teaching practices. Principals rated reform-oriented instructional practices as either *very important* or *important*. These reform-oriented instructional practices included providing inquiry-oriented activities, encouraging students to provide evidence for their answers, having teachers use questioning strategies, having students participate in appropriate hands-on activities, and having students working in cooperative groups. I found no significant difference between the way the principals from low and high-SES schools responded to the instructional practice questions ($p > 0.05$) (see Table A13).

Science Textbooks and Modules

Teachers were asked if they were using commercially published textbooks or modules, or non-commercially published materials. Sixty-eight percent of teachers responded that they were using only commercially published textbooks(s), 7% reported using only commercially published modules, 18% reported using both commercially published textbooks and modules, and 7% reported using only non-commercially published materials.

Textbooks and modules being used by teachers in at least two of the high science achieving schools can be found in Table 17. A large portion of the textbooks and modules reported as primary curriculum materials in the high-achieving schools (70%) were more than five years old. In addition, the other materials reported by schools were all more than five years old. A surprising finding was that 28% of the materials used to support science instruction in the high science achieving elementary schools in Idaho were textbooks, rather than science kits or modules. Principals reported an inadequate supply of science textbooks or modules as a moderate concern to impeding science instruction.

Table 17. Number of Teachers Reporting Use of Various Science Textbooks/Modules

	Textbook or Module		
Teachers	Publication Year	Publication Title	Publisher or Author
4	2007	Full Option Science Kits	Delta Education
2	Various	Delta Education Kits	Delta Education
4	2000	Discovery Works	Houghton Mifflin
4	2006	Science	Scott Foresman
4	2007	Science	Houghton Mifflin
3	2011	Science: A Closer Look	MacMillian
3	2000-2005	Harcourt Science	Harcourt
3	2012	Science Fusion	Houghton Mifflin
2	2011	National Geographic Science	National Geographic Learning

Teachers from high science achieving schools believe that incorporating activities from other sources to supplement their textbook or module is *very important* to promoting effective instruction. They also believe that picking out what is important from the textbook or modules and skipping the rest is *important*, while they ranked using the textbook or module to guide the overall or the detailed structure and content emphasis of the unit as only *moderately important*. I found no significant difference in these teacher views between the low and high-SES schools ($p > 0.05$).

When teachers from high science achieving schools supplement their curriculum, it is primarily because they believe they have a different activity that works better to support the science concept being taught (82%), they need a supplemental activity to provide students with additional practice (83%), or because they need a supplemental activity for students with different ability levels (88%). I found no significant difference in these teacher views between the low and high-SES schools ($p > 0.05$).

Reasons that teachers from high science achieving schools choose to skip activities in their curriculum included: lack of materials needed to implement the activity (62%) and the ideas addressed in the activity are not covered in their pacing guide (54%). I found no significant difference in these teacher views between the low and high-SES schools ($p > 0.05$).

Teachers mentioned module management systems in passing in their open-response statements, saying things like, “I receive my science kit units as other teachers are done with them, and fill in other times with units not needing kits.” Both low and high-SES principals viewed their district’s method of managing instructional resources, such as science modules, as *of little importance* in their ability to impede science instruction (*U* = 45, *z* = -0.83, *p* = 0.44).

Instructional Resources

The median ratings by the teachers for instructional resources and facilities were *somewhat adequate,* or the materials are available but quantities or the location of the items make coordinating the use of the items challenging. This rating was given to scientific equipment, instructional technology, consumable items, and facilities; see Table 18 for further details. I found no significant difference present between the teachers from low and high-SES schools on these items (*p* > 0.05).

Table 18. Median Teacher Ratings* on the Adequacy of Availability of Science Instructional Resources

	Teachers			
	Total (N=43) Median (IQR)	Low-SES (n=31) Median (IQR)	High-SES (n=12) Median (IQR)	Mann Whitney U-test, p-value
Equipment	3(3, 4)	3 (2, 4)	5 (3, 5)	*U* = 148, *z* = -1.06, *p* = 0.31
Instructional Technology	3(2, 4)	3 (2, 4)	4 (2, 4)	*U* = 184, *z* = -0.07, *p* = 0.95
Consumable Items	3(2, 4)	3 (2, 4)	4 (3, 4)	*U* = 125, *z* = -1.71, *p* = 0.10
Facilities	3(1, 3)	2 (1, 3)	3 (1, 5)	*U* = 133, *z* = -1.50, *p* = 0.15

* (1) Not available, (2) Limited availability (Present but not available for use), (3) Somewhat Adequate (Available, but quantities or location makes coordinating use challenging), (4) Nearly Adequate (In classroom, but limited quantities), (5) Adequate (In classroom in recommended quantities).

I calculated a composite score for adequacy of resources for instruction in science based on teachers' responses to items in Table 18. I found no significant difference between low and high-SES school teachers' responses on this composite ($p > 0.05$) (see Table 19).

Table 19. Median Composite Scores for Adequacy of Science Instructional Resources

Composite	Teachers			Mann-Whitney U test, p-value
	Total (N=40) Median (IQR)	Low-SES (n=28) Median (IQR)	High-SES (n=12) Median (IQR)	
Adequacy of Resources for Instruction in Science	50 (25, 63)	44 (25, 63)	44 (45, 72)	$U = 133$, $z = -1.44$, $p = 0.16$

Principals rated the lack of science facilities and inadequate materials for individualized instruction as being a moderate concern in their impact on science instruction. Principals also rated science instructional resource management as of little importance in its impact on science instruction. I saw these trends in the responses of principals from both low and high-SES schools ($p > 0.05$). I combined several questions from the principal survey to form a resource composite question looking at the extent to which a lack of materials and supplies are problematic. The data from this composite are displayed in Table 20.

Table 20. Median Composite Scores for the Extent to Which a Lack of Materials and Supplies are Problematic

Composite	Principals			Mann-Whitney U test, p-value
	Total (N=23) Median (IQR)	Low-SES (n=15) Median (IQR)	High-SES (n=8) Median (IQR)	
Lack of Resources is Problematic	47 (37.5, 70)	56 (37.5, 64)	41 (28, 84)	$U = 58$, $z = 0.14$, $p = 0.920$

When teachers were ask more specifically about the availability of science equipment and technology, a better picture of resource availability was revealed. Teachers reported that Internet access was readily available in *all or almost all* science classes, and computers/laptops and calculators are *often available, once or twice a week*. Handheld computers or tablets were *sometimes available, once or twice per month*. Items that were *never available* include triple beam balances and digital probes for collecting data. Simple balances and measurement tools (graduated cylinders, beakers, etc.) are *sometimes available, once or twice per m*onth, and microscopes are *rarely available, a few times a year*. I found no significant difference in what I found between low and high-SES schools for each of these items ($p > 0.05$). Surprisingly, though, the presence of classroom response or ‘clicker’ systems were found significantly more available in low-SES schools ($U = 316$, $z = 3.39$, $p = 0.001$). Low-SES school teachers reported ‘clickers’ as available *sometimes*, whereas high-SES school teacher reported that they were *never* available. For further details regarding this line of questioning see Table 21.

Table 21. Median Teacher Ratings* on the Availability of Specific Science Instructional Resources

Items	Teachers Total (N=40) Median (IQR)	 Low-SES (n=29) Median (IQR)	 High-SES (n=11) Median (IQR)	Mann Whitney U-test, p-value
Personal computers/laptops	4 (3,5)	4 (2,3)	4.5 (3.25, 5)	*U* = 137, *z* = -1.40, *p* = 0.18
Handheld Computers/Tablets	3 (1, 4.75)	2.5 (1, 4)	3 (1.25, 5)	*U* = 169, *z* = -0.64, *p* = 0.54
Internet Access	5 (3,5)	5 (3, 5)	5 (4.25 – 5)	*U* = 148, *z* = -1.21, *p* = 0.30
Digital Data Probes	1 (1,2)	1 (1,2)	1 (1,2)	*U* = 192, *z* = -0.02, *p* = 0.99
Microscopes	2 (2, 3.75)	2 (2, 3)	2.5 (1.25, 5)	*U* = 172, *z* = -0.56, *p* = 0.59
Classroom Response “Clickers”	2 (1,4)	2.5 (2, 5)	1 (1,1)	*U* = 316, *z* = 3.39, *p* = 0.001
Calculators	4 (3,5)	4 (3, 5)	4.5 (2.25, 5)	*U* = 176, *z* = -0.46, *p* = 0.67
Simple Balances	3 (2,5)	3 (2, 5)	2 (2, 5)	*U* = 174, *z* = -0.06, *p* = 0.97
Triple Beam Balances	1 (1,2)	1 (1, 1.75)	1 (1, 2)	*U* = 173, *z* = -0.64, *p* = 0.63
Liquid Measurement Tools	3 (2,4)	3 (2,4)	3.5 (3.5, 5)	*U* = 168, *z* = -0.51, *p* = 0.62

* (1) Never, (2) Rarely (A few times per year), (3) Sometimes (Once or twice per month), (4) Often (Once or twice per week), (5) All or almost all science classes.

As a final analysis of science resources, I calculated a composite score for the use of technology, from items found in Table 21. Analysis of these composite scores revealed no significant difference between low and high-SES school teachers' responses to the frequency of use of science instructional technology (see Table 22).

Table 22. Median Composite Scores for Use of Technology in Science Instruction

	Teachers			
Question Composite	Total (N=42) Median (IQR)	Low-SES (n = 30) Median (IQR)	High-SES (n=12) Median (IQR)	Mann-Whitney U test, p-value
Use of Technology	53 (40, 75)	50 (35, 75)	60 (50, 76)	U = 121, z = -1.19, p = 0.241

Funding for Science

Funding for science comes from various sources. The most common sources of funding are from state/district funding sources, community donations, teacher donations, and PTO fundraisers. I found no significant difference in funding between low and high-SES in the category of parent donations. Eighty-eight percent of high-SES school principals reported receiving funding from parent donations, as compared to only 27% of principals from low-SES schools. Although not statistically significant, 27% of low-SES principals reported receiving and spending federal funds (Title I or Title II) on science, as opposed to 0% of high-SES schools. For further breakdown of funding sources, see Table 23.

Table 23. Principal Reported, Percent of Schools that Receive Science Funding from Various Sources

	Principals			
	Total (N=23)	Low-SES (n=15)	High-SES (n=8)	Pearson’s Chi Square, p-value
State/District Funding	91%	87%	100%	$X^2(1) = 1.168$, *p*= 0.28
Title I Funding	14%*	20%*	0%*	$X^2(1) = 1.62$, *p*= 0.20
Title II Funding	5%*	7%*	0%*	$X^2(1) = 0.489$, *p*= 0.48
Parent Donations	48%	27%	88%	$X^2(1) = 7.74$, *p*= 0.01**
Community Donations	88%	40%	57%	$X^2(1) = 4.79$, *p*= 0.07**
Teacher Donations	74%	80%	63%	$X^2(1) = 0.829$, *p*= 0.36
Grants Received by Teachers	65%	60%	75%	$X^2(1) = 0.52$, *p*= 0.47
Grants Received by the School	48%	40%	48%	$X^2(1) = 1.059$, *p*= 0.30
Grants Received by the District	23%*	13%*	43%*	$X^2(1) = 2.2369$, *p*= 0.12
Fundraiser or PTO Funds	74%	67%	88%	$X^2(1) = 1.17$, *p*= 0.28

* N = 22 (nLow= 15, nHIGH= 7), ** Fisher’s Exact Test (2-sided) reported for p-value use, to prevent type two error, because of small sample size.

The total median dollars spent on science, at the building level, was reported by the participant principals to be only $300 during the last completed budget year (2012-2013); see Table 24 for a complete breakdown of how this money was spent. Principals from low and high-SES schools reported that inadequate funds for purchasing science equipment and supplies was an *important concern* ($U = 63$, $z = 0.46$, $p = 0.66$).

Table 24. Principal Reported Median Spending on Science during the Most Recently Completed Budget Year

	Dollars			Mann Whitney U-test, p-value
	Total (N=40) Median (IQR)	Low-SES (n=28) Median (IQR)	High-SES (n=12) Median (IQR)	
Consumable Science Supplies	\$300 (0,500)	\$300 (0,535)	\$250 (0,500)	$U = 56$, $z < 0.01$, $p = 1.0$
Science Equipment (Not including computers)	\$0 (0, 100)	\$50 (0,213)	\$0 (0,100)	$U = 52$, $z = -0.57$, $p = 0.64$
Software for Science	\$0 (0, 30)	\$0 (0, 158)	\$0 (0,0)	$U = 52$, $z = -0.67$, $p = 0.64$
Total	\$300 (0, 700)	\$510 (0,600)	\$200 (0,900)	$U = 63$, $z = 0.17$, $p = 0.88$

Promoting a Culture of Science or Engineering

When teachers and principals were asked what they do to promote the culture of science or engineering within their schools, no single activity was identified consistently across a large portion of the high science achieving schools; see Table 25 and Table 26. Approximately 20% of teachers indicated that they provided various after-school help clubs, support for fairs or competitions in science or engineering, or arranged guest speakers by individuals that worked in STEM careers. Teachers' beliefs about their support for these activities were lower than the principal responses, which hovered between 25-30%, regarding these same items. Thirty-nine percent of principals reported that their schools arranged opportunities for STEM mentors to participate in their schools, compared to 18% of teachers.

Table 25. Percent of Teachers who Reported that their Schools Provide Activities to Promote Science or Engineering

	Teachers			
	Total (N=44)	Low-SES (n=32)	High-SES (n=12)	Pearson's Chi square, p-value
Family Science/Engineering Night	39%	28%	6%	$X^2(1) = 5.47$, $p= 0.04$*
After-school Help in Science/Engineering	23%	25%	17%	$X^2(1) = 0.35$, $p= 0.56$
Science/Engineering Club(s)	23%	25%	17%	$X^2(1) = 0.35$, $p= 0.56$
Science/Engineering Fairs	16%	19%	8%	$X^2(1) = 0.71$, $p= 0.40$
Teams Participating in Science/Engineering Competition	20%	22%	17%	$X^2(1) = 0.15$, $p= 0.703$
Encourage Science/Engineering Summer Programs	43%	34%	67%	$X^2(1) = 3.71$, $p= 0.9$*
Visit Science/Engineering Related Community Sites	18%	19%	17%	$X^2(1) = 0.03$, $p= 0.87$
Adult Mentors From Science/Engineering Fields	18%	19%	17%	$X^2(1) = 0.03$, $p= 0.87$

* Fisher's Exact Test (2-sided) reported for p-value use, to prevent type two error, because of small sample size.

Teachers and principals also had conflicting views of their schools' support for after-school help in science or engineering. Twenty-three percent of teachers reported that they provide support in these areas, whereas only 13% of principals reported that their school provided support in these areas. The largest percentage of schools (43% of teachers and 65% of principals) said that they encouraged students to participate in science or engineering summer programs or camps. I found a significant difference in the number of teachers reporting that their schools provided family science or engineering nights. I found only 28% of low-SES teachers reported that science or engineering nights were provided at their schools, compared to 67% of high-SES teachers. I found no additional significant differences in teacher views between the low and high-SES schools ($p > 0.05$).

Table 26. Percent of Principals who Reported that their Schools Provide Activities to Promote Science or Engineering

	Principals			
	Total (N=44)	Low-SES (n=32)	High-SES (n=12)	Pearson's Chi square, p-value
Family Science/Engineering Night	32%*	21%*	5%*	$X^2(1) = 1.92$, $p= 0.17$
After-school Help in Science/Engineering	13%	7%	25%	$X^2(1) = 1.55$, $p= 0.21$
Science/Engineering Club(s)	26%	20%	38%	$X^2(1) = 0.83$, $p= 0.36$
Science/Engineering Fairs	26%	27%	25%	$X^2(1) = 0.008$, $p= 0.93$
Teams Participating in Science/Engineering Competition	26%	27%	25%	$X^2(1) = 0.008$, $p= 0.93$
Encourage Science/Engineering Summer Programs	65%	53%	88%	$X^2(1) = 2.69$, $p= 0.10$
Visit Science/Engineering Related Community Sites	26%	20%	38%	$X^2(1) = 0.83$, $p= 0.36$
Adult Mentors From Science/Engineering Fields	39%	63%	27%	$X^2(1) = 2.81$, $p= 0.09$

* N = 22 (nLow = 14, nHigh = 8)

Teacher Background and Professional Development

Teachers' Educational Background

Participant teachers gained their teaching certification from the Idaho State Department of Education through various paths. The majority of the teachers obtained their teaching certification through an undergraduate teaching program (87%) and the minority of them obtained their teaching certification through a master's program. A larger percentage (21%) of high-SES participant teachers obtained their certification through post-baccalaureate credit completion programs with no master's degree awarded, such as through the American Board of Certification of Teacher Excellence (ABCTE) program. See Table 27 for further information regarding participant teacher paths to certification.

Table 27. Percent of Teachers Taking Various Paths to Certification

	Teachers		
	Sample (N=47)	Low-SES (n=33)	High-SES (n=14)
An undergraduate program leading to a bachelor's degree and a teaching credential	87%	94%	71%
A post-baccalaureate credit completion program (no master's degree awarded)	9%	3%	21%
A master's program that also awarded a teaching certificate	4%	3%	7%
No formal certificate program completed	0%	0%	0%

Five participant teachers held graduate degrees, either Masters or Doctorate degrees in an education related field. Eighty-three percent of the teachers indicated that they held a Bachelor's degree in education. All but one of the teachers, 2%, held a

Bachelor's in Secondary Education. Only one participant teacher held a degree in a natural science or engineering field, and that degree was in a Biology related field. See Table 28 for a further breakdown of teacher participant educational background.

Table 28. Number and Types of Degrees Earned by Participant Teachers

	Teachers		
	Total (N=38)	Low-SES (n=26)	High-SES (n=12)
Degree in Education			
Elementary Education	3	26	12
Secondary Education	2	0	2
Masters, Doctorate, or second Bachelors in Education	8	5	3
Degree in Natural Sciences or Engineering			
Biological Sciences	1	0	1

The participant teachers reported that their science content knowledge came predominantly from introductory level biology (96% of the sample) and earth science (78% of the sample) coursework. Only 45% of the sample population had taken an introductory chemistry course and 38% had taken an introductory physics course. Six percent had taken an introductory Environmental Science course and 2% had taken an engineering course. This breakdown was similar for both low and high-SES school teachers; see Table 29 for a more complete breakdown.

Table 29. Percent of Teachers Reporting Completion of Introductory Coursework in Science and Engineering

	Teachers		
	Total (N=47)	Low-SES (n=35)	High-SES (n=12)
Chemistry	45%	46%	42%
Life Science	96%	100%	83%
Physics	38%	34%	50%
Earth/Space Science	79%	80%	75%
Environmental Science	38%	34%	50%
Engineering	2%	3%	0%

Thirty-four percent of the teacher sample had taken biology coursework beyond the introductory level, with the coursework coming predominately from courses on Anatomy and Physiology, Ecology, and Zoology. Only 2-8% of the teacher sample had taken courses beyond the introductory level in chemistry, physics, or earth science. One teacher, or 2% of the teacher sample, held a bachelor's degree in a science-related area (see Table A9).

The National Science Teachers Association (NSTA) has established elementary science teacher course background standards recommending that all elementary teachers have at least one college-level course in life, Earth, and physical science. Forty-seven percent of the participant teachers met these standards (see Table 30).

Table 30. Percent of Teachers Meeting the NSTA Course-background Standards

	Teachers		
	Total (N=47)	Low-SES (n=35)	High-SES (n=12)
Courses in life, Earth, and physical science	47%	49%	42%
Courses in two of the three areas	36%	34%	42%
Courses in one of the three areas	17%	17%	17%
No courses in any of the three areas	0%	0%	0%

The largest percentage of participant teachers (39%) last took a formal science course for college credit more than 10 years ago, with 15% of teachers reporting that they had never taken a formal science course for college credit. See Figure 10 for the remaining breakdown.

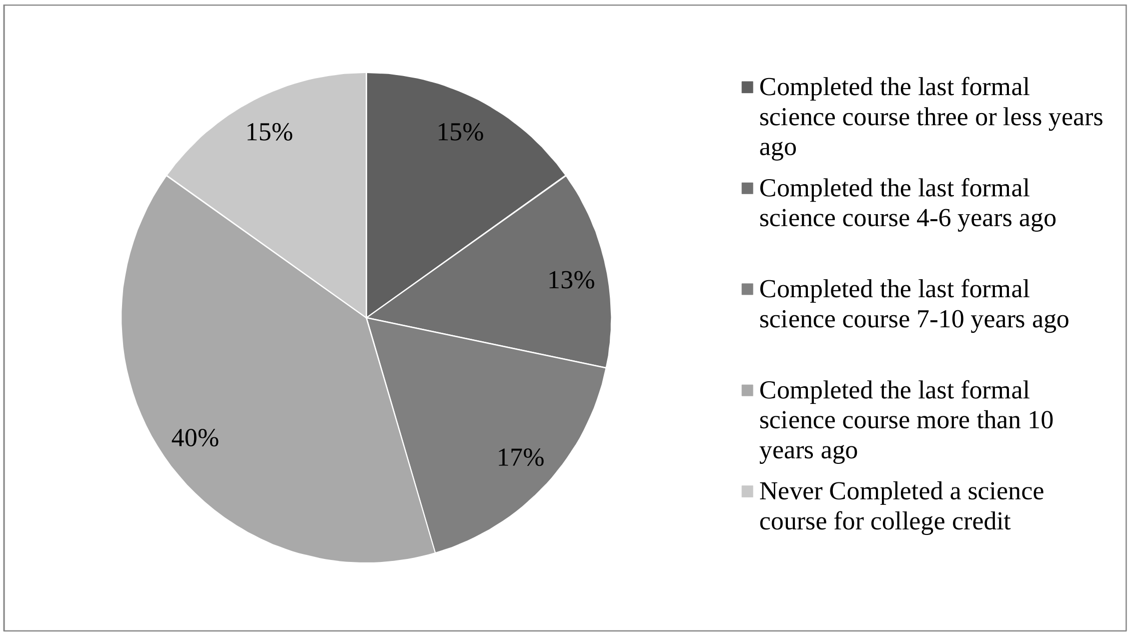


Figure 10. Percent of Teachers Completing Formal Science Courses, for College Credit

Similarly, the largest percentage of participant teachers last took a course in science pedagogy more than 10 years ago. A statistically significant difference arose between low and high-SES school teachers for this question ($p = 0.04$). Sixty-seven percent of high-SES school teachers reported having taken their last course in science pedagogy more than 10 years ago, whereas only 29% of low-SES school teachers reported having taken a course more than 10 years ago. A surprising 26% of participant teachers have never had a course in science pedagogy. I found no significant difference between low and high-SES school teachers ($p > 0.05$); see Figure 11 for a more complete breakdown of the data.

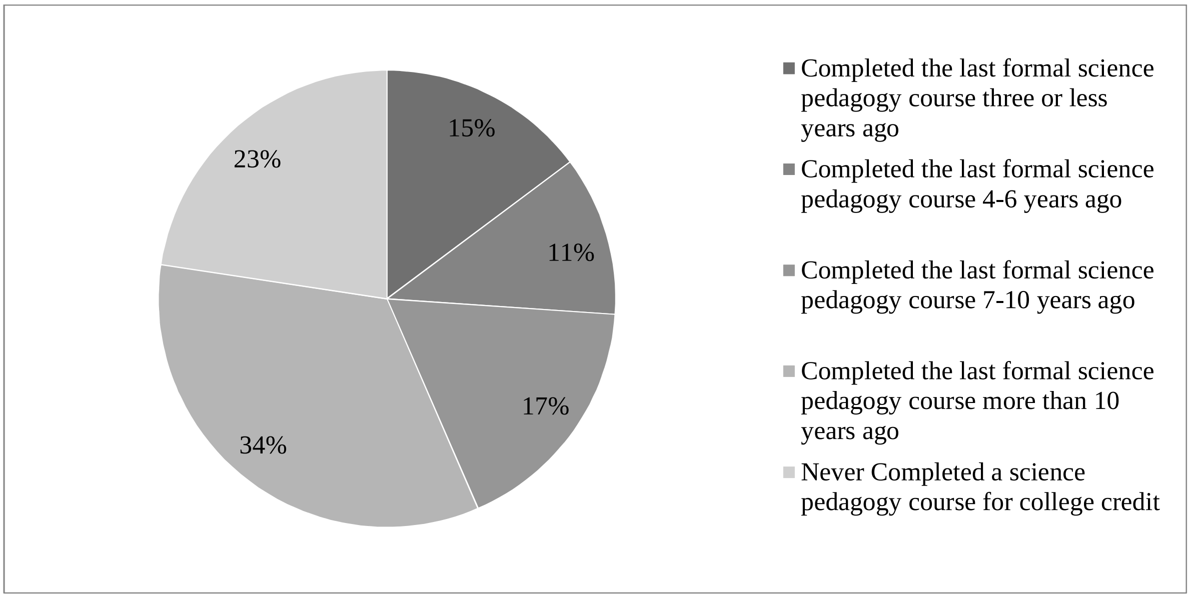


Figure 11. Percent of Teachers Having Taken Courses in Science Pedagogy

Teachers’ Feelings of Preparedness

Teachers were asked about their feelings of preparedness to teach various subjects areas. As can be seen in Table 31, teachers indicated that they felt *very well prepared* to teach mathematics and English language arts, and *fairly well prepared* to teach the life sciences, earth sciences, and social studies. However, teachers felt a deficit in their preparation to teach the physical sciences and engineering. Teachers in Idaho also felt a deficit in their preparation to teach science to students with learning disabilities and English language learners (ELL) students; see Table 32. Participant teachers did report that they felt *very well prepared* to manage classroom discipline during science instruction. I saw these trends in teacher preparedness in both low and high-SES schools and no significant difference exists between these sub-populations ($p > 0.05$); see Table 31 and Table 32.

Table 31. Median Teacher Ratings* on Feelings of Preparedness for Teaching Various Subject Areas

	Teachers			
	Total (N=34) Median (IQR)	Low-SES (n=33) Median (IQR)	High-SES (n=11) Median (IQR)	Mann Whitney U-test, p-value
Mathematics	4 (3, 4)	4 (3, 4)	4 (3,4)	*U* = 217, *z* = 0.95, *p* = 0.441
Reading/ELA	4 (3, 4)	4 (3, 4)	4 (3, 4)	*U* = 203, *z* = 0.52, *p* = 0.687
Social Studies	3 (2.25, 4)	3 (2.5, 4)	3 (2, 4)	*U* = 210, *z* = 0.81, *p* = 0.453
Life Science	3 (2, 3.5)	3 (2, 3.25)	3 (2, 4)	*U* = 183, *z* = -0.12, *p* = 0.93
Earth Science	3 (2, 3)	3 (2.75, 4)	3 (2, 3)	*U* = 242, *z* = 34.88, *p* = 0.152
Physical Sciences	2 (2, 3)	2.5 (2, 3)	2 (2, 3)	*U* = 187, *z* < 0.01, *p* = 1.0
Engineering	2 (1, 2)	2 (1,2)	2 (1, 2)	*U* = 202, *z* = 0.43, *p* = 0.71

* (1) Not adequately prepared, (2) Somewhat prepared, (3) Fairly well prepared, (4) Very well prepared.

When principals were asked about teacher preparedness, they indicated that their teachers had been adequately prepared by teacher preparation programs to teach science, and that their teachers had adequate science knowledge and interest in science. I found no significant difference in the responses of low and high-SES principals on this line of questioning (p > 0.05).

Table 32. Median Teacher Ratings* on Feelings of Preparedness for Teaching Various Student Populations

	Teachers			
	Total (N=45) Median (IQR)	Low-SES (n=33) Median (IQR)	High-SES (n=12) Median (IQR)	Mann Whitney U-test, p-value
Learning Disabilities	2 (2, 3)	2 (2, 3)	2 (2, 3)	$U = 207$, $z = 0.08$, $p = 0.94$
Physical Disabilities	2.5 (2, 3)	2.5 (2, 3)	2.5 (1.25, 3)	$U = 218$, $z = 0.37$, $p = 0.71$
ELL	2 (2, 3)	2 (2, 3)	2 (1.25, 3)	$U = 207$, $z = 0.08$, $p = 0.94$
Gifted & Talented	3 (2., 3)	2.5 (2, 3)	3 (2, 3.75)	$U = 170$, $z = -0.91$, $p = 0.36$
Females in STEM	3 (2.75, 4)	3 (2.75, 4)	3 (2, 4)	$U = 219$, $z = 0.40$, $p = 0.69$
Minorities in STEM	3 (2.75, 4)	3 (2.75, 4)	3 (2.25, 4)	$U = 200$, $z = -0.11$, $p = 0.92$
Low-SES in STEM	3 (3, 4)	3 (2.75, 4)	3 (3, 4)	$U = 215$, $z = 0.28$, $p = 0.78$

* (1) Not adequately prepared, (2) Somewhat prepared, (3) Fairly well prepared, (4) Very well prepared.

As a final analysis of teachers' perceptions of preparedness, I calculated composite scores from questions that addressed teachers' perception of preparedness to teach diverse learners and perceptions of preparedness to encourage students. These composite scores are available in Table 33.

Table 33. Composite Scores for Teacher Perceptions of Preparedness Questions

Question Composites	Teachers Total (N=40) Median (IQR)	Low-SES (n=28) Median (IQR)	High-SES (n=12) Median (IQR)	Mann-Whitney U test, p-value
Perception of Preparedness to Teach Diverse Learners	47 (33 67)	47 (33, 62)	50 (33, 67)	U = 198, z = -0.16, p = 0.87
Perceptions of Preparedness to Encourage Students	67 (50, 100)	67 (50, 100)	67 (46, 100)	U = 206, z = 0.20, p = 0.85

Professional Development

Twenty-nine percent of principals indicated that their school or district had offered professional development focused on science or science teaching in the last three years. Principals indicated that the most common methods of providing professional development time for teachers' professional growth came from the use of: early dismissal or late start for students (67%); professional days or teacher workdays during the students' school year (67%); and common planning time for teachers (67%). I found no significant difference between low and high-SES school principals ($p > 0.05$).

Fifty-six percent of participant teachers reported that they had participated in science or science teaching focused professional development in the last three years. Twenty-two percent of participant teachers have never participated in science or science teaching focused professional development. Only 8% of the teacher sample indicated that they had attended a national, regional, or state science association meeting. I did not find a significant difference between low and high-SES school teachers for this line of questioning ($p > 0.05$).

Of the teachers that indicated that they have participated in science or science teaching focused professional development: 96% of them had participated in science or science teaching focused workshops; 8% had attended a national, state, or regional science association meeting; and 50% have participated in professional learning community, lesson study, or teacher study groups focused on science or science teaching. The hours spent by each of the teachers that reported they completed science or science teaching focused professional development are available in Figure 12. The largest percentage of teachers completed less than six hours (40%); the second largest percentage of teachers completed more than 35 hours (36%).

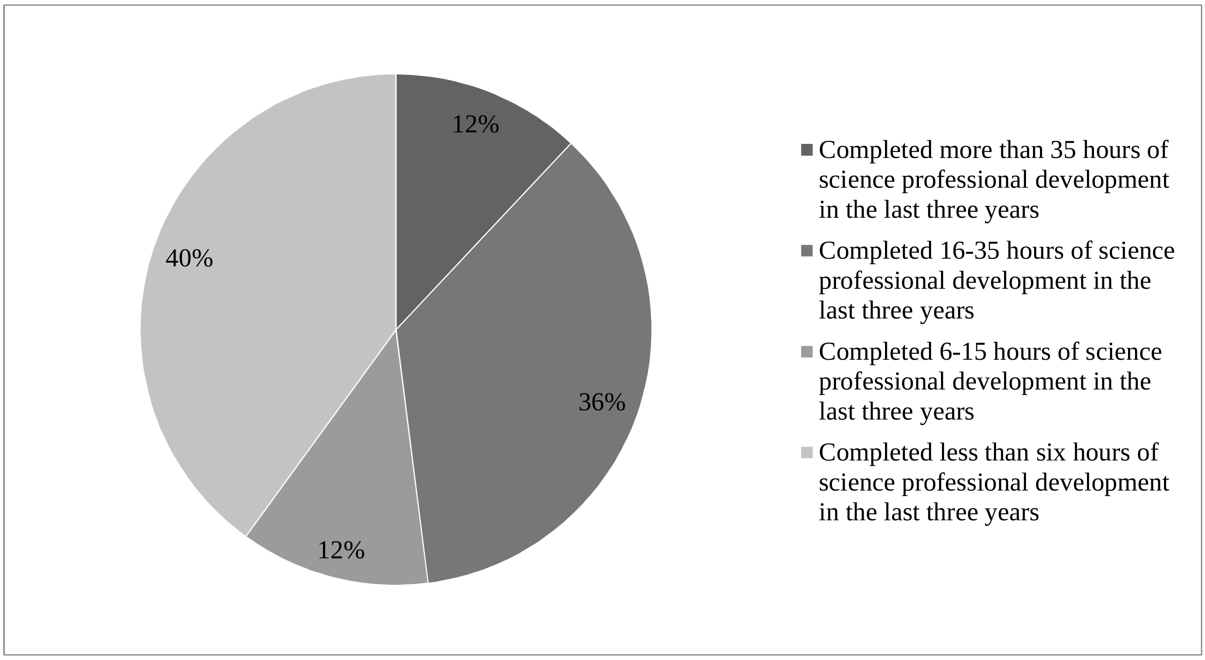


Figure 12. Percentage of Teachers Participating in Professional Development

Professional development experiences that teachers took part in provided the following opportunities to a *considerable extent*: opportunities to engage in science investigations; opportunities to try out what they learned in their classroom and then talk about this experience as part of the professional development; work closely with other science teachers from their school; and work closely with science teachers from the same grade level or subject area.

Table 34. Teachers Beliefs about the Focus Placed on Various Instructional Components, During Professional Development, Over the Last Three Years

Professional Development Focus of Importance		
Limited Extent (2)	Moderate Extent (3)	Considerable Extent (5)
Learning about the difficulties that students may have with particular science ideas and procedures	Planning instruction so students at different levels of achievement can increase their understanding of the ideas targeted in each activity	Deepening science content knowledge
Discovering what students think or already know about the key science ideas prior to instruction	Monitoring student understanding during science instruction	
Implementing science textbook or module adopted by the district or school	Assessing student understanding at the conclusion of instruction on a topic	
Providing enrichment experiences for gifted students		
Providing alternative science learning		
Teaching science to ELL students		

Participant teachers reported that the professional development opportunities that they participated in over the last three years placed a range of importance on various issues facing science education. Table 34 presents issues facing science education and the level of importance that the professional development coordinators assigned to each of these issues, as perceived by the teacher participants, during various professional development opportunities. I found no significant difference between low and high-SES school teachers on these items ($p > 0.05$).

When principals were asked about the same focus of science professional development in their schools and districts, over the last three years, their responses indicated a heavy emphasis on the Common Core State Standards and integrating science with other content areas. Every principal (100%) indicated that these two instructional components were the focus of science professional development in their districts over the last three years. Teachers reported that science content was focused on to a considerable extent in professional development, yet only 22% of principals believe that science content was a focus of professional development. I found no significant difference between low and high-SES school principals ($p > 0.05$). Principals reported that insufficient time to teach science was an important concern, and they found inadequate science-related professional development opportunities to be a moderate concern.

I found a significant difference between teacher responses of low and high-SES school teachers when they were asked if their schools or districts had participated in any STEM initiatives over the last five years ($p = 0.01$). High-SES school teachers, with a smaller sample size of 12, reported that 83% of their schools or districts had participated in STEM initiatives. Only 37% of low-SES school teachers (sample of 35) reported that their schools or districts had participate in STEM initiatives. This is a surprising finding because I found no significant difference between low and high-SES school principals, when asked the same question ($p > 0.05$). Forty-three percent of principals reported that their schools or districts had participated in a STEM initiative within the last five years.

The high-SES sample size of principals was eight, and low-SES principal sample size was 15.

I calculated teacher composite scores for several areas of teacher professional development, including, quality of professional development and extent to which professional development (PD) and coursework focused on student-centered instruction. The composite scores for each of these categories are presented in Table 35.

Table 35. Composite Scores for Teacher Professional Development Questions

	Teachers			
Question Composites	Total (N=40) Median (IQR)	Low-SES (n=28) Median (IQR)	High-SES (n=12) Median (IQR)	p-value
Quality of Professional Development	37.5 (27, 50)	37.5 (26, 55)	29 (25, 46)	0.458
Extent to Which PD/Coursework Focused on Student-centered Instruction	43.75 (25, 62.5)	44 (31, 56)	62.5 (20, 68.75)	0.585

Instructional Leadership and Mandate

Teachers as Leaders

Over the last three years, only a small number of teachers have participated in various teacher leader roles. Some of these leadership roles included: *teaching in-service workshop(s) on science or science teaching* (5%); *serving as a formally assigned mentor or coach for science teaching* (5%); and *supervising student teacher(s)* (33%). I found no significant difference in these findings between teachers from low and high-SES schools.

Teachers reported that they *rarely* have influence on how money is spent and students *rarely* have direct influence on decisions. The participant teachers felt they *sometimes* play a role in school-wide decision-making, input on plans for professional development and growth, and participation in decisions about school improvement (see Table 36). Questions regarding teachers' roles in school decision-making were used to calculate a composite score on shared leadership (see Table 37). I found no significant difference between low and high-SES school teacher responses for the individual questions on shared leadership or the shared leadership composite.

Table 36. Median Ratings* by Teachers on Shared Leadership within their School Buildings, During the 2013-2014 School Year

	Teachers			
	Total (N=43) Median (IQR)	Low-SES (n=30) Median (IQR)	High-SES (n=13) Median (IQR)	Mann Whitney U-test, p-value
Influence on Money Spending	2 (2, 3)	2 (2, 3)	2 (2, 3)	*U* = 178, *z* = -0.23, *p* = 0.84
Role in School-wide Decision Making	3 (2, 3)	3 (2, 3)	3 (2, 3)	*U* = 191, *z* = 0.13, *p* = 0.90
Significant Input into PD plans	3 (2, 4)	3 (2, 3)	3 (2, 4)	*U* = 180, *z* = -0.18, *p* = 0.86
Principal Ensures Wide Participation in School Improvement Decisions	3 (3, 4)	3 (2, 4)	3 (3, 4)	*U* = 164, *z* = -0.64, *p* = 0.547
Students have Direct Influence on School Decisions	2 (1,3)	2 (1,4)	2 (1, 2)	*U* = 222, *z* = 1.01, *p* = 0.34
School Teams have Influence on School Decisions	3 (2,4)	3 (2,4)	3 (2, 4)	*U* = 187, *z* = 0.03, *p* = 1.00

* (1) Never, (2) Rarely (A few times per year), (3) Sometimes (Once or twice per month), (4) Often (Once or twice per week), (5) All or almost all science classes.

Table 37. Composite Scores for Shared Leadership

Question Composite	Teachers Total (n=43) Median (IQR)	 Low-SES (n=30) Median (IQR)	 High-SES (n=13) Median (IQR)	p-value
Shared Leadership Composite	42 (33, 58)	42 (33, 58)	40 (30, 55)	0.841

Principals as Instructional Leaders, Observation and Feedback

A large number of principals reported (73%) that they did provide observation and feedback of science instruction during this school year. I found no significant difference between principals of low and high-SES schools ($x^2(1) = 0.87$, $p = 0.35$).

When teachers were asked how often they were formally observed during science instruction during this school year, a significant difference was found between the teachers in low and high-SES schools ($p< 0.05$). Thirteen percent of low-SES school teachers reported that they had been observed during formal observation this school year, whereas 77% of the high-SES school teachers reported that they had been formally observed during science instruction. Likewise, the median number of formal science observations in low-SES schools was 0 (0,0) and the median number of formal science observations of the high-SES school teachers was 1 (0.25, 2). This difference in observation times between low and high-SES school teachers is statistically significant ($U = 63$, $z = -4.23$, $p = 0.001$).

Table 38. Percent Teacher Reported Observational Occurrences, During the 2013-2014 School Year

Science Observation or Feedback	Teachers			Pearson's Chi-square, p-value
	Total (N=43)	Low-SES (n=30)	High-SES (n=13)	
Formal Observation	33%	13%	77%	$X^2(1) = 13.66$, $p < 0.049$*
Informal Observation/ Walkthrough	70%	70%	69%	$X^2(1) = 0.08$, $p = 0.783$
Received Feedback on Science Instruction	35%	23%	62%	$X^2(1) = 7.40$, $p = 0.01$*
Received Specific Feedback on Reform-minded Science Practices	16%	13%	23%	$X^2(1) = 0.93$, $p = 0.35$

* Fisher's Exact Test (2-sided) reported for p-value use, to prevent type two error, because of small sample size.

When participant teachers were asked about informal observations of their science instruction, the findings between low and high-SES school teachers were not significantly different. The median times observed during informal or walk-through observations for the participant teachers was 1 (0, 2) occurrence during this school year. Seventy percent of participant teachers indicated that they had been observed during science instruction during an informal or walk through observation. For additional information, please see Table 38 and Table 39.

Table 39. Median Number of Teachers Reported Observational Occurrences, During the 2013-2014 School Year

Science Observation	Observational Occurrences of Teachers Total (N=43) Median (IQR)	Low-SES (n=30) Median (IQR)	High-SES (n=13) Median (IQR)	Mann Whitney U-test, p-value
Formal Observation	0 (0, 1)	0 (0, 0)	1 (0.25, 2)	$U = 63$, $z = -4.23$, $p = 0.001$
Informal Observation/ Walkthrough	1 (0,2)	1 (0, 2)	0.5 (0, 2.75)	$U = 224$, $z = 0.80$, $p = 0.46$

When observing, 76% of principals indicated they look for reform-minded science practices, and 88% of them reported providing specific feedback on how teachers can improve science instruction. When teachers were asked about feedback that they receive on their science instruction, a significant difference was found between low and high-SES school teachers (*p*= 0.01). Twenty-three percent of low-SES teachers received specific feedback on their science instruction, whereas 62% of high-SES teachers received specific feedback on their science instruction. A significant difference was not found, however, between low and high-SES school teachers when they were asked about feedback on reform-minded science practices. Only 16% of participant teachers received specific feedback that was reform-minded (inquiry, learning cycle, evidence based responses, etc.) (see Table 38).

Support for Struggling Teachers in Science

I found no significant difference between low and high-SES school principals in the support structure that they reported putting in place for struggling teachers in science. Table 40 provides an overview of the services provided.

Table 40. Percent of Principals Reportedly Using Interventions to Help Struggling Teachers in Science

Intervention	Principals			Pearson's Chi-square, p-value
	Total (N=22)	Low-SES (n=14)	High-SES (n=8)	
Seminars, classes, or study groups	14%	7%	25%	$X^2(1) = 1.38$, $p= 0.24$
Higher Level of Supervision than for Other Teachers	41%	36%	50%	$X^2(1) = 0.43$, $p= 0.51$
Guidance from a Formally Designated Mentor or Coach	41%	43%	38%	$X^2(1) = 0.06$, $p= 0.81$

Science Mentors and Coaches

I found a significant difference in the number of teachers reporting that they had received feedback about their science teaching from a mentor or coach that was formally assigned by the school or district ($p = 0.01$). Only 16% of low-SES teachers received feedback from a formally assigned mentor or coach, while 58% of high-SES teachers received feedback from a formally assigned mentor or coach. When teachers were asked about mentorship and coaching, few respondents indicated that these roles exist in their schools or districts. A small percentage of teachers indicated that their principal (2%), district science supervisor or coordinator (7%), teachers who have no classroom teaching responsibilities in the district (5%), and teachers with full-time teaching responsibilities in the district (12%), filled coaching or mentoring roles in their district. These numbers were similar to what the principals reported, except that the principles reported that 23% saw themselves as filling this mentoring or coaching role in their school. I found no additional significant difference in responses from teachers or principals, from low and high-SES schools ($p>0.05$).

Science Professional Learning Communities

Twenty-six percent of participant principals reported that in the last 5 years their school offered teachers study groups where teachers meet on a regular basis to discuss teaching and learning of science. During these study groups, principals indicated that teachers primarily plan science lessons together, analyze students' science assessment results, and analyze science instructional materials. Zero percent of the teacher sample reported that they had led a professional learning community, lesson study, or teacher study groups focused on science or science teaching. When teachers were asked about participation in professional learning communities, lesson study, or teacher study groups focused on science or science teaching, 50% reported that they had participated in one of these types of learning communities within the last three years. I found no significant difference between low and high-SES school principals ($p > 0.05$).

Instructional Leadership

Teachers were asked about their principals' instructional leadership skills; the median teacher response indicates that teachers felt as though their principals *sometimes* observed their science classroom instruction. Teachers reported that their principals *rarely* provided specific ideas to improve instruction and *rarely* attended teacher planning meetings. The teachers indicated that their principals *never* make suggestions on classroom management. I found one significant difference in the data between low and high-SES school teachers on instructional leadership ($p = 0.04$). The high-SES school teachers said that their principals *all or almost always* protect teachers from distractions to their instruction, and the low-SES school teachers said that their principals only *sometimes* protect their instructional time (see Table 41).

Table 41. Median Ratings* by Teachers on their Principals' Instructional Leadership

	Teachers			
	Total (N=43) Median (IQR)	Low-SES (n=30) Median (IQR)	High-SES (n=13) Median (IQR)	Mann Whitney U-test, p-value
Principal has discussed instructional issues with you	2 (2, 3)	2 (2, 3)	2 (1, 3)	$U = 228$, $z = 1.20$, $p = 0.27$
Principal observed your classroom instruction	3 (2, 3)	3 (2, 3)	3 (2, 3)	$U = 181$, $z = -0.15$, $p = 0.90$
Principal has made suggestions for improve classroom behavior or classroom management	1 (1, 2)	1 (1, 2)	1 (1, 3)	$U = 186$, $z = -0.02$, $p = 1.00$
Principal has attended teacher planning meetings	2 (2, 3)	2 (2, 3)	2 (2, 3)	$U = 185$, $z = -0.03$, $p = 1.00$
Principal provides you specific ideas for how to improve your instruction	2 (1, 2)	2 (1, 2)	2 (1, 3)	$U = 139$, $z = -1.41$, $p = 0.20$
Principal protects teachers from distractions to their instruction	4 (2, 5)	3 (1, 4)	5 (4, 5)	$U = 108$, $z = -2.17$, $p = 0.04$
Principal has clearly defined standards for instructional practices	3 (2, 5)	3 (2, 5)	4 (2, 5)	$U = 159$, $z = -0.75$, $p = 0.48$

* (1) Never, (2) Rarely (A few times per year), (3) Sometimes (Once or twice per month), (4) Often (Once or twice per week), (5) All or almost all science classes.

I calculated composite scores on instructional leadership from questions items found in Table 41. This composite score did not reveal a significant difference between low and high-SES school teachers responses on instructional leadership (*U* = 143, *z* = -1.17, *p* = 0.68) (see Table 42).

Table 42. Composite scores for Instructional Leadership

	Teachers			
Question Composites	Total (n=43) Median (IQR)	Low-SES (n=30) Median (IQR)	High-SES (n=13) Median (IQR)	Mann-Whitney U test, p-value
Instructional Leadership Composite	46 (39,54)	46 (39,57)	45 (34,54)	*U* = 143, *z* = -1.17, *p* = 0.68

Assessment and Feedback

Types of Assessment

Formative, summative, and performance assessments are all reportedly used by approximately 80% of sampled teachers (see Table 43). A similar percentage of principals reported that summative and performance assessments were used in their schools. However, only 68% of principals believed that formative assessment was used in their school to assess science. Eighty-three percent of teachers reported aligning their assessments to district or state standards, which is consistent with what principals reported. Diagnostic assessments to determine prior knowledge were used by only 63% of the sampled teachers; similarly, 50% of principals reported that diagnostic assessments were used in their schools. Student self-assessment was reportedly used by 46% of teachers; however, 55% of principals believed this method of assessment was used in their school. I found no significant difference in these findings between the low and high-SES schools.

Table 43. Percentage of Teachers Reporting the Use of Various Types of Science Assessment

Assessment Type	Teachers			Pearson Chi-square, p-value
	Total (N=42)	Low-SES (n=30)	High-SES (n=12)	
Diagnostic Assessment	63%*	61%*	67%*	X^2(1) = 0.13, p= 0.72
Formative Assessment	80%**	76%**	92%**	X^2(1) = 1.35, p= 0.25
Summative Assessment	79%	77%	83%	X^2(1) = 0.23, p= 0.63
Performance Assessment	88%	87%	92%	X^2(1) = 0.20, p= 0.65
Science Notebooks	76%	77%	75%	X^2(1) = 0.01, p= 0.91
Student Self-Assessment	46%**	45%**	50%**	
Alignment of Assessment to State/District Standards	83%**	79%**	92%**	X^2(1) = 0.92, p= 0.34

* N= 40 (nLOW= 28, nHIGH=12), ** N=41 (nLOW=29, nHIGH= 12)

Only 33% of teachers had their students use rubrics to assess other classmates' work. Over 90% of teachers reported using various forms of informal assessments to evaluate their students' understanding of the material. These informal assessments included: questioning, reviewing students' work, and informal observations. The majority of teachers reported that they used science journals (76%). However, only 5% of principals reported the use of science journals in their schools. I found no significant difference in these findings between low and high-SES school teachers ($p < 0.05$).

Table 44. Percentage of Teachers Reporting Changes in Whole Class Science Instruction Based on Data

Change	Teachers			Pearson's Chi-square, p-value
	Total (N=41)	Low-SES (n=29)	High-SES (n=12)	
Change Lesson Plans to Emphasize Areas which the Class Scored Low	85%	83%	92%	$X^2(1) = 0.54$, $p= 0.46$
Add more Projects and Exercises in Areas that the Class Scored Low	76%	72%	83%	$X^2(1) = 0.55$, $p= 0.46$
Request Additional Supplies or Equipment	44%	38%	58%	$X^2(1) = 1.44$, $p= 0.23$
Re-evaluate Textbooks and Learning Materials	63% **	75% **	33% **	$X^2(1) = 6.22$, $p= 0.03$*
Discuss Curriculum Relevance and Alignment to Standards with Peers	71%	76%	58%	$X^2(1) = 1.26$, $p= 0.26$
Ask for Additional Support and Ideas from Peers or Administrators	83%	86%	75%	$X^2(1) = 0.75$, $p= 0.39$

* Fisher's Exact Test (2-sided) reported for p-value use, to prevent type two error, because of small sample size; ** N= 40 (nLOW= 28, nHIGH=12)

I found a significant difference between low and high-SES school's teacher response to whether or not they participated in re-evaluating textbooks and learning materials ($p = 0.03$). Teachers from low-SES schools were more likely to say that they re-evaluated curriculum materials based on assessment results than were high-SES teachers (see Table 44).

Table 45. Percentage of Principals Reporting Changes Teachers Make in Whole Class Science Instruction Based on Data

Change	Principals Total (N=21)	Principals Low-SES (n=13)	Principals High-SES (n=8)	Pearson's Chi-square, p-value
Change Lesson Plans to Emphasize Areas Which The Class Scored Low	65%*	67%*	63%*	$X^2(1) = 0.04$, $p = 0.85$
Add more Projects and Exercises in Areas that the Class Scored Low	62%	62%	63%	$X^2(1) = 0.002$, $p = 0.965$
Request Additional Supplies or Equipment	57%	62%	50%	$X^2(1) = 0.27$, $p = 0.60$
Re-evaluate Textbooks and Learning Materials	57%	54%	63%	$X^2(1) = 0.15$, $p = 0.70$
Discuss Curriculum Relevance and Alignment to Standards with Peers	88%	69%	76%	$X^2(1) = 0.91$, $p = 0.34$
Ask for Additional Support and Ideas from Peers or Administrators	86%	85%	88%	$X^2(1) = 0.36$, $p = 0.55$

* N = 20 (nLOW= 12, nHIGH= 8)

I found no significant difference between principals' responses to this question. Fifty-seven percent of principals reported that their teachers re-evaluated textbooks and learning materials based on assessment (see Table 45). Surprisingly, only 44% of teachers reported that they request additional supplies or equipment. This finding was similar to what principals reported (57%). I found no significant difference in this finding between teachers or principals from low and high-SES schools. The majority of teachers asked for additional support and ideas from other teachers or administrators (83%) and discussed curriculum relevance, alignment to standards, and assessment with their peers (71%). See Table 44 for further details; there was no statistical difference in these findings between low and high-SES school teachers.

Struggling Students

Although the sample teachers were likely to provide struggling students with additional assistance during class in areas they perform poorly (85%), they were more likely to provide these same poorly performing students with materials on test-taking skills and strategies (70%) than they were to provide them with assistance outside of class (48%). The teachers were also not likely to provide high-performing students with additional, more challenging projects or readings (54%) (see Table 46).

Table 46. Percentage of Teachers Implementing Various Strategies for Helping Struggling Students in Science

Strategies	Teachers			Pearson's Chi-square, p-value
	Total (N=40)	Low-SES (n=28)	High-SES (n=12)	
Provide Students Additional Assistance in Class in Areas they Performed Poorly	85%**	82%	91%**	$X^2(1) = 0.47$, $p= 0.50$
Provide Students Additional Assistance Outside of Class in Areas they Performed Poorly	48%	50%	42%	$X^2(1) = 0.23$, $p= 0.63$
Provide Poorly Performing Students Material on Test-taking Skills and Strategies	70%	82%	42%	$X^2(1) = 6.55$, $p= 0.02$*
Provide High-performing Students with Additional, Challenging Projects or Readings	54%***	56%***	50%	$X^2(1) = 0.10$, $p= 0.75$

* Fisher's Exact Test (2-sided) reported for p-value use, to prevent type two error, because of small sample size; ** N= 39 (nLOW= 28, nHIGH=11); ***N=39(nLOW= 27, nHIGH=12)

The results of the teacher survey are slightly different from the principals' beliefs about their teachers (see Table 47). A high percentage of principals said that their teachers provide students additional assistance in class in areas in which the students are performing poorly (90%), and 52% of the principals believe that teachers provided support outside of class. Principals also believe that only 48% of their teachers are teaching struggling students test-taking strategies. See Table 46 and Table 47 for additional information about struggling students.

Table 47. Percentage of Principals Reporting their Teachers Implement Various Strategies for Helping Struggling Students in Science

Strategies	Principals			Pearson's Chi-square, p-value
	Total (N=21)	Low-SES (n=13)	High-SES (n=8)	
Provide Students Additional Assistance in Class in Areas they Performed Poorly	90%	92%	88%	$X^2(1) = 0.13$, $p= 0.72$
Provide Students Additional Assistance Outside of Class in Areas they Performed Poorly	52%	62%	38%	$X^2(1) = 1.15$, $p= 0.28$
Provide Poorly Performing Students Material on Test-taking Skills and Strategies	48%	46%	50%	$X^2(1) = 0.03$, $p= 0.86$
Provide High-performing Students with Additional, Challenging Projects or Readings	71%	69%	75%	$X^2(1) = 0.08$, $p= 0.78$

Monitoring Student Progress and Achievement

Overall, the sampled teachers felt fairly well prepared to monitor students' progress and achievement during the last science unit they taught; see Table 48.

Table 48. Median Ratings* by Teachers on their Level of Preparedness to Monitor Student Progress and Achievement During the Last Science Unit They Taught

Activity	Teachers: Total (N=40) Median (IQR)	Teachers: Low-SES (n=28) Median (IQR)	Teachers: High-SES (n=12) Median (IQR)	Mann-Whitney U test, p-value
Anticipate Student Difficulties with Particular Science Concepts	3 (2.25, 3)	3 (2, 3.75)	3 (3, 3)	$U = 191$, $z = 0.75$, $p = 0.512$
Identify Student Prior Knowledge Before Beginning Unit	3 (3, 4)	3 (2.25, 3.75)	3 (3, 4)	$U = 193$, $z = 0.59$, $p = 0.601$
Implement Science Lessons from Textbook or Module	3 (3,4)	3 (3, 4)	3 (3, 4)	$U = 164$, $z = -0.32$, $p = 0.788$
Monitor Students Understanding During the Unit	3 (3, 4)	3 (3, 4)	3 (3, 4)	$U = 171$, $z = -0.12$, $p = 0.921$
Assess Student Understanding At the Conclusion of the Unit	3 (3, 4)	3 (3, 4)	3 (3, 4)	$U = 157$, $z = -0.59$, $p = 0.621$

* (1) Not adequately prepared, (2) Somewhat prepared, (3) Fairly well prepared, (4) Very well prepared.

Sixty-four percent of principals reported that they did monitor student progress in science. I found no significant difference between principals from low and high-SES schools. Only 36% of teachers believed that their principals made an effort to monitor student progress in science. I found no significant difference between teachers from low and high-SES schools. Evidence that teachers provided of their principals monitoring progress in science most commonly involved monitoring of ISAT results and student report cards. Their examples also included: monitoring of grade-level assessment content; support of science fairs; interactions with students during observations of science lessons; and monitoring of objectives during classroom visits.

Table 49. Principal Median Composite Score for the Supportive Context for Science Instruction

Question Composite	Principals			Mann-Whitney U test, p-value
	Total (N=23) Median (IQR)	Low-SES (n=15) Median (IQR)	High-SES (n=8) Median (IQR)	
Supportive Context for Science	31.25 (22, 50)	31.25 (18.75, 47)	28 (20, 61)	*U* = 49, *z* = -0.26, *p* = 0.804

I calculated a composite score from principal responses on the supportive context for science instruction. These data are presented in Table 49. A composite score was also calculated using teacher responses for the extent to which policy environment promotes effective instruction; these data are presented in Table 50.

Table 50. Teacher Median Composites for Extent to which the Policy Environment Promotes Effective Instruction

Question Composite	Teachers			Mann-Whitney U test, p-value
	Total (N=40) Median (IQR)	Low-SES (n=28) Median (IQR)	High-SES (n=12) Median (IQR)	
Extent to which the Policy Environment Promotes Effective Instruction	54 (37.5, 62.5)	52 (37.5, 61)	56 (42, 79)	*U* = 123, *z* = -0.97, *p* = 0.35

CHAPTER FIVE: DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

Introduction

It has become a national goal to increase the number of students entering STEM careers. Elementary science education has been identified as important in laying the foundation for intellectual development, the foundation of scientific literacy, and an entry point into interests in STEM. If Idaho shares in the national goal of increasing STEM literacy, it will be necessary for Idaho schools to make elementary science a priority. With so many competing interests in education, it is important to know how to invest resources to get the greatest return. With this in mind, it is important to identify what factors at the school and classroom level are important in achieving success in elementary science.

The purpose of this study was to identify if the four key elements to elementary science reform are present within Idaho's high science achieving elementary schools, and to identify if differences exist in the implementation of the key elements between low and high-SES schools. To better understand this purpose, I developed two focused research questions:

- *Question 1:* In Idaho, are all of the four key elements present in all of the high science achieving elementary schools? This question was further broken into four sub-questions:

  - Is there evidence of the element Programs and Practices found within all of the high science achieving elementary schools in Idaho?
  - Is there evidence of the element Teacher Background and Development found within all of the high science achieving elementary schools in Idaho?
  - Is there evidence of the element Instructional Leadership and Mandate found within all of the high science achieving elementary schools in Idaho?
  - Is there evidence of the element Assessment and Feedback found within all of the high science achieving elementary schools in Idaho?
- *Hypothesis 1*: Based on three years of science ISAT results, the identified Idaho schools have consistently developed high achievers in science (ISDE, 2011a, 2012a, 2013a). As a state, Idaho has scored above the national average on the last National Assessment of Educational Progress (NAEP) test given in the elementary grades (NCES, 2011). The NAEP test is a rigorous test that tests beyond rote knowledge, making it reasonable to believe that evidence will be present in all of the highest science achieving schools in the state that indicates they are engaged in delivering all four key elements considered important to achieving success in elementary science.
- *Question 2*: In Idaho, high science achievement can be found in both low and high socioeconomic status elementary schools. Does the evidence indicate a difference between the low and high-SES schools' implementation of the key elements to

elementary science reform in Idaho high science achieving schools? This question was further broken into four sub-questions:

  - Is there a difference in the implementation of Programs and Practices between Idaho low and high-SES, high science achieving elementary schools?
  - Is there a difference in the implementation of Teacher Background and Development between Idaho low and high-SES, high science achieving elementary schools?
  - Is there a difference in the implementation of Instructional Leadership and Mandate between Idaho low and high-SES, high science achieving elementary schools?
  - Is there a difference in the implementation of Assessment and Feedback between Idaho low and high-SES, high science achieving elementary schools?

- *Hypothesis 2*: Based on the different pressures created by socioeconomic status in low and high-SES schools, the ability to implement each of the key elements will be different in the high science achieving, high and low-SES schools.

Discussion

I have organized the discussion section by the four key elements, addressing each in the following order: (1) Programs and Practices, (2) Teacher Background and Development, (3) Instructional Leadership and Mandate, and (4) Assessment and Feedback. I have considered each research question within the context of each of the key elements to elementary science reform, first by the total sample, then by the differences between the two sub-populations (low and high-SES schools).

I further synthesized the data within the summary sections for each of the key elements. To achieve this, I identified primary indicator items from the teacher survey, principal survey, and composite questions to identify the presence of each key element. The presence of the primary indicators then provided further insight into which schools were implementing each of the key elements. This process allowed me to quantify my first research question, “Is there evidence that all of the participant Idaho high science achieving schools are activating the key element Program and Practice?” A description of how the presence of each primary indicator item was determined is provided within each of the key element summary sections.

To maintain anonymity, I randomly assigned pseudonyms to each of the participant schools. Each school’s pseudonym is an element from the periodic table of elements. Once the names were randomly assigned, I then ordered the schools by their elemental periodic number.

Programs and Practices

Program and Practice encompasses both the quality and quantity of the adopted instructional program and instructional practice within a school. A quality program is identifiable by the adoption, implementation, and support of high-quality instructional materials and instructional practices that meet state and district standards, and are consistent with the higher-order vision of the National Science Standards or the Next Generation Science Standards. The quantity of a program is identifiable by the number of hours dedicated to weekly instruction of science (Inverness Research Associates, 2006a, 2006b, 2007; St. John et al., 2007).

Using data from the teacher and principal surveys, I looked for evidence to support the presence of Programs and Practices in the entire sample (Question 1), and within the sub-populations (Question 2). The evidence I looked for focused on both the quality and quantity of the elementary science programs and practices reportedly implemented at the school and classroom level. For the quality of instruction, I was interested in identifying the mean hours per week that the schools reported implementing science instruction. I looked for evidence of how teachers were implementing their science instruction, and if their reported practices were consistent with the definition of high-quality science instruction, as outlined in Chapter One. I looked for evidence of a school culture that supported effective science instruction and helped all students to succeed in elementary science. Additionally, I looked at the resources and funding available to implement high-quality instruction.

To address question one, I will begin by considering the sub-question on Programs and Practices. I evaluated the total principal and teacher samples for evidence of the entire Idaho sample activating the Programs and Practices within each of the seven sub-categories: (1) time for science instruction; (2) promoting effective science instruction; (3) science teaching practices; (4) science textbooks/modules; (5) instructional resources; (6) funding for science; and (7) promoting a culture of science or engineering. I then followed each of these sub-categories with an evaluation of the evidence within the context of research question two.

Time for Science Instruction

When the third through fifth grade teachers at high science achieving elementary schools were asked about how much time they devoted to teaching the various core subject areas, I found that teachers spent significantly less time on science instruction compared to ELA (English Language Arts) and math instruction (see Figure 8 and Table A10). For the purpose of comparison, I broke these numbers down into per day means. As can be seen in Table 51, this trend is mirrored nationally in third through fifth grade classrooms (Trygstad, 2013). I found no significant difference in these trends between low and high-SES schools ($p > 0.05$).

Table 51. Minutes Per Day of Instruction in Third through Fifth Grade Classrooms Across Content Various Areas

Content Area	3rd–5th grade Idaho Participant Teacher Sample	3rd–5th grade National Teacher Sample (Trygstad, 2013)
English Language Arts (ELA)	90 minutes per day	84 minutes per day
Mathematics	70 minutes per day	60 minutes per day
Science	27 minutes per day	22 minutes per day
Social Studies	26 minutes per day	19 minutes per day

The quantity of elementary science instruction occurring within high science achieving Idaho schools is consistent with the state mean. When Idaho teachers were asked how much time they committed to science instruction on the NAEP teacher survey, they reported a mean of two hours per week, ranking one of the lowest time commitments in the nation (Blank, 2012). The highest scoring states reported budgeting three to four hours per week for science instruction (Blank, 2012). Surprisingly, Idaho's mean two-hour time commitment was similar to the median two hours per week reported by high science achieving school teachers. These results indicate that the median high science achieving schools in the state of Idaho do not have an increased quantity of instruction present in their schools, as compared to other Idaho schools; in fact six teachers, from four different schools, reported providing an hour or less of science instruction per week. The science ISAT identified some schools as high achieving in science that are not budgeting the time necessary to implement high-quality science instruction.

I found no significant difference in the quantity of science instruction reported by teachers of low and high-SES students ($p>0.05$). However, when I calculated the hours per week of science instruction based on a 36-week school year, the trend showed that low-SES teachers were budgeting more time for science than the high-SES teachers. This is an interesting finding; however, it is not necessarily an indication of the quality of science instruction taking place.

Science Teaching Practices

Inverness Research Associates (2006b) and Heenan and Helms (2013) found that some districts had success in building capacity for science reform within their schools through the use of lead teachers, specialists, and science resource teachers. When I looked at science instruction at the school level, I found 39% of the high science achieving Idaho teachers reported that within their schools science instruction was taught by someone other than the elementary core teacher, such as a specialist or a teacher on their grade-level team (see Table 10). Nationally, 18% of teachers reported that someone provided science instruction other than the elementary core teacher, such as a specialist or a teacher on their grade-level team (Banilower et al., 2013). These Idaho schools reported taking advantage of a larger number of designated specialists or grade-level teachers acting as specialists than what Banilower et al. (2013) reported nationally. However, my finding is consistent with what Inverness Research Associates observed in a large number of schools actively implementing science reform (Heenan & Helms, 2013; Inverness Research Associates, 2006a, 2006b; St. John et al., 2007, 2008). I found no significant difference between the way that low and high-SES schools organized and staffed their science teachers ($p > 0.05$).

When I analyzed the quality of science instruction in Idaho at the school level, I found Idaho high science achieving schools made a marked improvement from what was reported in the 2009 fourth grade science NAEP teacher survey results. In 2009, only 35% of the Idaho teachers surveyed by the NAEP reported providing hands-on/laboratory-based science instruction *daily, or once or twice weekly* (Blank, 2012). When Idaho teachers were asked about providing hands-on/laboratory-based science instruction for this study, 53% of teachers indicated that they conducted these activities *daily, or once or twice per week.*

When I considered the sub-populations, I found a statistical difference between the low and high-SES school teacher responses. The high-SES school teachers' median responses indicated that they conducted hands-on activities *once or twice a week*, while the low-SES school teachers median response indicated that they conducted hands-on activities only *once or twice per month* ($U = 105$, $z = -2.32$, $p = 0.03$). When I looked at the teaching composite focused on identifying the importance placed, by teachers, on reform-oriented teaching practices, the composites revealed higher scores in the high science achieving Idaho schools than what Banilower et al. (2013) found in a national study of science education (see Table 52).

Table 52. Idaho Teacher Sample vs the National Teacher Sample Responses on Reform-Oriented Teaching Composites

Composite	Median Idaho Teacher Sample Median (IQR)			Mean National Teacher Sample (Banilower et al., 2013)
	Total	Low-SES	High-SES	
Reform-Oriented Instructional Objectives	90 (80, 95)	*	*	79 (0.7)
Use of Reform-Oriented Teaching Practices	67 (50, 79)	63 (50, 75)	79 (63, 88)	60 (0.7)

* Not significantly different

The median composite scores calculated for *Reform-Oriented Instructional Objectives* were not statistically significant between low and high-SES schools (U = 107, z = -1.86, p = 0.07), indicating both low and high-SES school teachers identify the importance of reform-oriented teaching to a higher level than what was found in the national sample (Banilower et al., 2013). A significant difference was found between the low and high-SES schools for the *Use of Reform-Oriented Teaching Practices* composite. Although both low and high-SES schools implement reform practices, high-SES schools implement reform practices significantly more often (U = 97, z = -2.11, p = 0.04).

Despite the findings that the Idaho high science achieving schools are doing better at the classroom level on the quality of science instruction, Programs and Practice is not present in all of the schools identified by the science ISAT as high achieving. Eight out of 20 (40%) participant schools had teachers that reported engaging their students in multiple high-quality science practices *once or twice a week* or *all or most science lessons*. These practices included: engaging students in hands-on/laboratory-based instruction, asking students to represent and/or analyze data using tables, charts, and graphs; and requiring students to supply evidence in support of their claims (see Table 54).

Promoting Effective Science Instruction

At the school level, teachers identified various factors as *important* in promoting effective science instruction: principal support; time for them to plan individually and with colleagues; and time for professional development. Factors identified as being *moderately important* were: standards; pacing guides; state science testing; textbook or module selection policies. I found a difference between low and high-SES school teachers' views on the importance of the district science curriculum framework (U = 101, z = -2.07, p = 0.045). Teachers in high-SES schools indicated that the district curriculum framework was *important*, and teachers in the low-SES schools saw the district science curriculum framework as *moderately important*. I found no additional significant difference between low and high-SES schools on these factors ($p > 0.05$).

At the school level, it was interesting to find that only 6% of participant principals reported being knowledgeable of the Next Generation Science Standards. Principals saw lack of opportunities for science teachers to share ideas as a *moderately important* factor that needed to be addressed. I did not find any significant difference in the responses of low and high-SES principals on this line of questioning ($p > 0.05$).

Science Textbooks or Modules

Research by Banilower et al. (2006) found the use of well-written curriculum and good instructional materials greatly improves the quality of science instruction. Their research indicated that when teachers implemented well-designed materials in the way they were originally intended, the lessons were more likely to be highly rated in providing significant and worthwhile content, providing developmentally appropriate content, and for portraying science as a dynamic body of knowledge. Unfortunately, they also found that the vast majority of elementary classrooms in the United States do not have this level of support. They found that teachers are often forced to improvise lessons and gather their own materials. Their study went on to further show that only 11% of teacher improvised lessons received a rating of high-quality in providing significant and worthwhile content, developmentally appropriate content, and for portraying science as a dynamic body of knowledge (Banilower et al., 2006).

When the Idaho teachers participating in this study were asked how they used their assigned textbook or module, they reported that picking out what is important from the textbook or module and skipping the rest was *important in promoting effective instruction*. They also believed that incorporating activities from other sources to supplement where the textbook or module was lacking was *very important in promoting effective instruction*. The largest number of teachers (82%) said the reason they skipped activities in their textbook or modules was because they had different activities for those science ideas that work better than the ones they skipped. Other common reasons for skipping the material included: the science ideas covered were not in their pacing guides (54%) and they didn't have the materials to implement the activities (62%).

Nearly 40% of the commercially published textbooks or modules reportedly used in the high science achieving schools were published in 2006 or earlier. Some textbooks being used were as much as 14 years old. The American Association for the Advancement of Science (2002) has been critical of textbook quality, particularly at the elementary and middle school level in science. Not only are a large percent of textbooks outdated, very few of the textbooks or modules went through a rigorous development process. Historically, elementary science products created with funding from the National

Science Foundation are known to be well-vetted and of high quality. Only 14% of the commercially published textbooks or modules being used by the high science achieving schools in Idaho were developed with funding from the National Science Foundation. Based on the data collected from the teacher survey, it appears that not all of the schools have the level of support present in their assigned science curriculum consistent with a high-quality instructional program.

Instructional Resources

Lack of adequate resources for science instruction cannot only affect the quality of instruction, it can prevent instruction from occurring (Goldsmith & Pasquale, 2002). When instructional resources were evaluated at the school level, teachers in high science achieving elementary schools in Idaho gave the availability of instructional resources a median rating of *somewhat adequate*, meaning materials are available, but quantities or the location of the items makes coordinating the use of the items challenging. Teachers also reported that scientific equipment, instructional technology, consumable items, and facilities were only *somewhat adequate*. When I looked to identify how many schools reported access to scientific equipment and consumable items, I found that only 4 out of 20 schools (20%) had *nearly adequate* or *adequate* access to these items. I also found that only 8 out of 20 schools (40%) had *nearly adequate* or *adequate* access to science facilities. I found no significant difference between the teachers from low and high-SES schools on these items ($p > 0.05$).

Teachers reported that Internet access was *readily available*, in all or almost all science classes, and computers/laptops and calculators were *often available*, once or twice a week. Handheld computers or tablets were *sometimes available*, once or twice per month. Teachers reported they never had access to digital probes for data collection. I found no significant difference between low and high-SES schools for each of these items ($p > 0.05$). Surprisingly, though, the presence of classroom response or ‘clicker’ systems were found significantly more ($U = 316$, $z = 3.39$, $p = 0.001$) in low-SES schools than in high-SES schools. The teachers from low-SES schools said they *sometimes* had access to ‘clickers,’ whereas the high-SES school teachers said they *never* had access to them.

At the school level, principals rated the lack of science facilities and inadequate materials for individualized instruction as a *moderate concern* in its impact on science instruction. Principals also rated science instructional resource management as of *little importance* in its impact on science instruction. This finding is surprising, since based on the teacher survey results it is apparent that the majority of schools are lacking in easy access to the materials they need to implement high-quality science instruction. Additionally, the research by Goldsmith and Pasquale (2002) indicates that a lack of adequate resources for science instruction is prohibitive, stopping instruction all together or reducing the quality of instruction.

The principals’ survey composite median score for *lack of materials and supplies is problematic* was 47 (37.5, 70) out of 100. The national survey reported a mean score of 42 (1.8), indicating that principals around the nation have similar concerns about inadequate materials and supplies for elementary science instruction (Banilower et al., 2013). These trends can be seen in the responses of principals from both low and high-SES schools ($p > 0.05$).

Similarly, the composite score for the *adequacy of resources for instruction in science* revealed a median score of 50 out of 100 points (25, 63). The same composite calculated from the national data had a mean score of 48 (1.4), indicating that Idaho high-SES schools reported a stronger adequacy of science resources than what was found nationally (Banilower et al., 2013). I found no significant difference between the low and high-SES schools for this composite score (U = 133, z = -1.44, p = 0.16).

It is evident that not all of the high science achieving schools have easy access on a weekly basis to the scientific resources needed to implement high-quality science instruction. It is also evident that at the school level not all the schools' leadership has an understanding of how the lack of materials affects the quality of science instruction.

Funding for Science

Administrators control access to budgetary resources and often make judgments about instructional materials. When there is a lack of budgeting for materials and replacement costs, instruction is affected. Often this completely prevents high-quality instruction from getting off the ground (Goldsmith & Pasquale, 2002). The current economic climate in the United States has brought about deep cuts in education across the country. Idaho is no exception. The results of this study show that even high science achieving schools are not making science a priority in their budgets. The total median dollars budgeted for science by the high science achieving schools was only 300 dollars per school during the last completed budget year (2012-2013). I found no significant difference in spending behaviors in science between low and high-SES principals.

Dorph et al. (2011) found that teachers in schools serving higher percentages of students in poverty were more likely to report lack of facilities and resources as a major challenge to providing science instruction than teachers from affluent schools. In Idaho, principals from both low and high-SES schools reported that inadequate funds for purchasing science equipment and supplies was an *important concern* ($U = 63$, $z = 0.46$, $p = 0.66$). Idaho schools' funding for science comes from various sources. The most common sources of funding were from state/district funding sources, community donations, teacher donations, and PTO fundraisers. I found a significant difference in funding between low and high-SES in the category of parent donations. Eighty-eight percent of high SES school principals reported receiving funding from parent donations, as compared to only 27% of principals from low-SES schools. It was surprising to see that 74% of principals reported that teacher donations were a source of funding for science instruction.

When budgets are tight, it becomes even more crucial to seek external funding and resources to support science (Dorph et al., 2011; Spillane et al., 2001). However, Dorph and associates (2011) discovered that most schools do not seek out external funding. Principals from Idaho's high science achieving elementary schools reported that they have received funding from a variety of sources (see Table 23), including teacher initiated grants. These data indicated that the high science achieving schools have sought out external funding. However, with budgetary medians of only 300 dollars a year per school, it is difficult to understand how they have received significant amounts of external funding. It is evident that not all of the high science achieving schools have developed budgetary support for their science programs.

Promoting a Culture of Science or Engineering

When teachers and principals were asked what they do to promote the culture of science or engineering within their schools, no single activity was identified consistently across a large portion of the high science achieving schools (see Table 25 and Table 26). Approximately 20% of teachers indicated that they provided various after-school help clubs, support for fairs or competitions in science or engineering, or arranged guest speakers representing STEM careers. Teachers' beliefs about their support for these activities were lower than the principal responses, which hovered between 25 – 30%, regarding these same items. When these results were compared to the national data collected by Banilower et al. (2013), it appeared that the Idaho high science achieving sample provided more family science or engineering nights (39%) and more opportunities for students to participate in science or engineering clubs (23%) than what the national sample of teachers reported, 26% and 7%, respectively. However, the national sample of teachers reported greater opportunity for after-school help in science or engineering (31%) and greater opportunities to participate in local or regional science or engineering fairs (35%), as opposed to 23% and 16% of Idaho high achieving science school teachers, respectively. I found no significant differences between low and high-SES school teachers and principals on questioning related to promoting a culture of science or engineering.

Question 1: Sub-question on Program and Practice

Analysis at the school and classroom level, using the teachers' and principals' survey results, has provided insight into the key element Programs and Practices within high science achieving elementary schools in Idaho. The Question 1: Program and

Practice sub-question I asked was, “Is there evidence that all of the participant Idaho high science achieving schools are activating the key element Program and Practice?” The answer to this question is no; the evidence does not support that all the Idaho high science achieving schools activate the key element Program and Practice. To quantify the presence of the key element Program and Practice, I chose seven primary indicator items. These primary indicators were chosen from the teacher survey items and from one question composite. These primary indicator items and the methods used to indicate the presence of the primary indicators are presented in Table 53.

Table 53. Program and Practice Primary Indicator Items and Criteria for Indicating their Presence

Question Number(s)	Primary Indicator	Criteria for Indicating Items Presence
Use of Reform-Oriented Teaching Practices Composite, Reform-Oriented Instructional Objectives Composite	Reform-Oriented Teaching Practices and Instructional Objectives	The majority of teachers at each school reported a score greater than the National Mean (60) on the Reform-Oriented Teaching Practices Composite and a score greater the National mean (79) on Reform-Oriented Instructional Objectives Composite.
Teacher Survey Q4.7_4	Doing hands-on/laboratory activities	The mean teachers’ responses from a given school of *Often* or *All or Most All Science Lessons* were counted.
Teacher Survey Q4.7_8	Having students represent or analyze data using tables, charts, or graphs	The mean teachers’ responses from a given school of *Often* or *All or Most All Science Lessons* were counted.
Teacher Survey Q4.7_9	Requiring students to supply evidence in support of their claims	The mean teachers’ responses from a given school of *Often* or *All or Most All Science Lessons* were counted.
Teacher Survey Q4.8_7, 4.8_8	Visiting STEM sites or having guest speakers from STEM fields	The mean teachers’ responses from a given school of *Yes* to either question 4.8_7 or 4.8_8.were counted.
Teacher Survey Q4.9_1, 4.9_3	Access to Science Equipment and Consumable Items	The mean teachers’ responses from a given school of *Nearly Adequate* or *Adequate* to both 4.9_1 and 4.9_3 were counted.

However, 18 of the 20 schools (90%) have some aspect of Programs and Practices present in their schools. Seven of the 20 participant high science achieving schools (35%) had teachers that reported strong support for elementary science in the area of Program and Practice on the questions from the teacher and principal surveys shown in Table A14. These seven schools represented three low and four high-SES schools. They are located within three different regions of Idaho and represent both rural and urban schools.

Question 2: Sub-question on Program and Practice

Question two focuses on the differences found between low and high-SES schools in the implementation of Programs and Practices. The Programs and Practices sub-question was, “Is there a difference in the implementation of Programs and Practices between Idaho low and high-SES, high science achieving elementary schools?” The evidence does support a significant difference between low and high-SES schools in Programs and Practices. Although both low and high-SES reported more reform-based instruction, as compared to Idaho in 2009 and the national data, low-SES school teachers reported significantly fewer reform-based teaching methods than high-SES schools ($p < 0.05$) (Banilower et al., 2013; Blank, 2012). Since both low and high-SES teachers reported similar amounts of time dedicated to the various instructional disciplines, and similar support from parents and community for science, I cannot conclude that there were any different social pressures between low and high-SES schools ($p > 0.05$). I can conclude that there were some differences in the pressures between low and high-SES schools within Program and Practice, since low-SES school principals reported significantly less funding for science, in the area of parent donations ($p = 0.01$), than high-SES principals.

The next key element that I will focus my discussion on is Teacher Background and Development.

Teacher Background and Development

Teacher background encompasses a teacher’s years experience as an educator, and their formal education in teaching pedagogy and science content. Teacher development comes from the access to professional development that focuses on both pedagogy and content. The highest quality PD comes from sustained professional development (50+ hours) that promotes collaborative approaches, builds strong relationships among teachers, connects to classroom practice, and focuses on teaching and learning specific academic content (Heenan & Helms, 2013).

Using data from the teacher and principal surveys, I looked for evidence to support the presence of Teacher Background and Development in the entire sample (Question 1), and within the sub-populations (Question 2). The evidence I looked for focused on teachers’ knowledge and background in science, feelings of preparedness to teach science, and opportunities for teachers to gain professional development in science content and pedagogy. I was interested in identifying how the teachers’ background in science, feelings of preparedness, and opportunities to gain professional development compared with what Banilower et al. (2013) saw in their national study on science education. I first evaluated the total principal and teacher samples looking for evidence of the entire Idaho sample meeting the Teacher Background and Development criteria. Then, I evaluated the low-SES schools and high-SES schools’ samples on the same Teacher Background and Development criteria to determine if both sub-populations met the criteria for Teacher Background and Development separately.

Teachers' Educational Background

The Idaho teachers' backgrounds in science is not vast, but it is beyond the national average for elementary teachers (Trygstad, 2013). Participant teachers gained their teaching certification from a variety of sources, with the majority of the teachers (87%) gaining their teaching certification through an undergraduate teaching program, as compared to only 52% of a national sample of third through fifth grade teachers (Trygstad, 2013). Eighty-three percent of the participant teachers held a bachelor's degree in education. One participant teacher held a bachelor's degree in the biological sciences. Five participant teachers obtained graduate Master's or Doctorate degrees in an education related field. I found no significant difference between low and high-SES school teachers ($p > 0.05$).

The participant teachers reported that their science content knowledge came predominantly from introductory level biology, followed by introductory Earth science (see Table 29). My findings are similar to what Trygstad (2013) found in the national third through fifth grade sample from the 2012 National Survey of Science and Mathematics Education study, see Table 54 (Trygstad, 2013). I found no significant difference between low and high-SES school teachers ($p > 0.05$).

Table 54. Percentage of Teachers Completed Introductory Science Courses, A Comparison between Idaho High Science Achieving School Teachers and the Nation

	3rd–5th grade Teachers	
	Idaho High Science Achieving Sample (n=40)	National Sample (n=443)*
Life Science	96%	87%
Earth/Space Science	79%	65%
Chemistry	45%	47%
Physics	38%	34%
Engineering	2%	2%

*(Trygstad, 2013)

Thirty-four percent of the teachers sampled had taken biology coursework beyond the introductory level. However, only 2-8% of the teachers sampled had taken courses beyond the introductory level in chemistry, physics, or Earth science. This breakdown is reflective of teachers' perceptions of preparedness to teach physical science and engineering. I found no significant difference between low and high-SES school teachers ($p > 0.05$).

The course-background standards for elementary science teachers developed by the National Science Teachers Association (NSTA) recommends all elementary teachers have at least one college-level course in life, Earth, and physical science. Forty-seven percent of the participant teachers met these standards. This is higher than the national average of 36% of third through fifth grade teachers meeting NSTA's course-background standards (Trygstad, 2013).

Teachers' Feelings of Preparedness

At the classroom level, Idaho high science achieving teachers were asked about their feelings of preparedness to teach various subjects areas; the median sample felt *very well prepared* to teach mathematics and English language arts/reading, and *fairly well prepared* to teach the life sciences and earth sciences. The median teacher sample, however, felt a deficit in their preparation to teach the physical sciences and engineering. This trend mirrors what Trygstad (2013) found in third through fifth grade elementary teachers nationally.

Idaho teachers reported a deficit in their preparation to teach science to students with learning disabilities and English language learner (ELL) students. Nationally, 52%

(3.8) of third through fifth grade teachers felt better prepared to teach students with a learning disability and 48% (3.6) felt prepared to teach ELL students (Trygstad, 2013).

It is well known that managing an active inquiry-based science lab can be a challenge, yet participant teachers reported they felt *very well prepared* to manage classroom discipline during science instruction. I found these trends in teacher preparedness in both low-SES and high-SES schools, and no significant difference existing between these sub-populations. This trend was also mirrored in the national data, with 96% (2.1) of third through fifth grade teachers feeling prepared to manage classroom discipline during science instruction (Trygstad, 2013). It is unknown whether the teachers answered this question picturing “management of students during science instruction” as the management of an active environment in which students are engaged with groups of students investigating scientific phenomena, or if they viewed “management of science instruction” as student sitting at their desks engaged with a text or listening to instruction.

I calculated composite scores for teachers’ perception of preparedness to teach diverse learners and perceptions of preparedness to encourage students. I found no significant difference between low and high SES on these measures. I have provided a comparison of these composites for the Idaho high science achieving sample and the national sample in Table 55 (Banilower et al., 2013). The results of this comparison show that Idaho’s high science achieving school teachers felt less prepared to encourage students in science and teach diverse learners in science than the national sample of third through fifth grade teachers.

Table 55. Composite Scores for Teacher Background Perceptions of Preparedness Questions, Comparison between Idaho High Science Achieving Sample and the National Sample

	Teachers	
Composite	Idaho High Science Achieving (N=40) Median (IQR)	National (n= 443)* Mean (SD)
Perception of Preparedness to Teach Diverse Learners	35 (25, 50)	53.5 (24.7)
Perceptions of Preparedness to Encourage Students	50 (37.5, 75)	65.9 (28.2)

*(Trygstad, 2013)

At the school level, I found that the participant principals believed that teacher preparation programs had adequately prepared their teachers. I did not find significant differences in the responses of low and high-SES principals on this line of questioning ($p > 0.05$).

Professional Development

In an Idaho study on where teachers go for content and pedagogical support, Nadelson et al. (2013) found that teachers most often access people they know and are physically present. This study's findings support the findings of Nadelson et al. (2013). Eighty-three percent of the high science achieving elementary school teachers in this study reported that they asked for additional support and ideas from other teachers or their school's principals when making changes to whole-class instruction, based on data. Additionally, two teachers volunteered that they sought help in the form of information and resources from their spouses who were secondary-level science teachers. Teachers' responses indicated they were much less likely to seek out formal assistance through professional development and formal science courses. Only 56% of the teachers sampled reported having taken a science or science teaching focused professional development course in the last three years. Fifteen percent of teachers sampled had taken a formal science course in the last three years.

A recent survey of California educators, administrators, and districts conducted by Dorph et al. (2011) found that although almost 90% of elementary teachers felt prepared to teach English language arts, only one third of those surveyed felt prepared to teach science. Similarly, this study found that the median feeling of preparedness for teaching English language arts and mathematics was *very well prepared*, compared to the only *somewhat prepared* feelings of preparedness to teach physical science and engineering, and *fairly well prepared* to teach life and earth science.

Dorph et al. (2011) reported elementary science professional development scarce, with only 15% of the teachers surveyed having received science-related professional development in the last three years. This finding is not consistent with what the high science achieving Idaho school teachers reported, with 56% of the teachers having participated in professional development focused on science or science teaching in the last three years. Although Idaho teachers are less likely to seek out formal assistance from professional development, they are engaging in science related professional development more often than that found by Dorph et al. (2011). This is an important finding, because research indicates that in order to make science more accessible to the elementary school teachers, professional development is key to increasing content knowledge and pedagogical skills.

Schools overcame busy schedules and fit in teacher professional development through a variety of creative scheduling techniques. At the school level, principals reported the time for teacher professional growth came primarily from the use of early dismissal or late start for students (67%), professional days or teacher workdays during the students' school year (67%), and common planning time for teachers (67%). I found no significant difference between low and high-SES school principals ($p > 0.05$).

Question 1: Sub-question on Teacher Background and Development

Analysis of the teacher and principal survey results has provided insight into the Teacher Background and Development key element within high science achieving elementary schools in Idaho. The Teacher Background and Development sub-question I asked was, "Is there evidence that all of the participant Idaho high science achieving schools are activating the key element Teacher Background and Development?" The answer to this question is no; the evidence does not support all of the Idaho high science achieving schools having teachers that feel *very* or *fairly well prepared* to teach the sciences, nor do all the teachers meet the NSTA's core curriculum requirements. To quantify the presence of the key element Teacher Background and Development, I chose five primary indicator items. These primary indicators came from teacher survey items and from two question composites. These primary indicator items and the methods used to indicate the presence of the primary indicators are presented in Table 56.

Table 56. Teacher Background and Development Primary Indicator Items and Criteria for Indicating their Presence

Question Number(s)	Primary Indicator	Criteria for Indicating Items Presence
Teacher Survey Q3.25_1,2,3,4,5,6, 10	Access to Science-Focused Professional Development	The mean teachers' responses from a given school of *To a Considerable Extent or To a Great Extent* to three or more of these questions were counted.
Teacher Survey Q2.23_1,2,3,4,5	Access to High-Quality Science Professional Development	The mean teachers' responses from a given school of *To a Considerable Extent or To a Great Extent* to two or more of these questions were counted.
Teacher Survey Q2.26_3	Teacher(s) feel prepared to teach life, earth, and physical science content	The mean teachers' responses from a given school of *Very Well Prepared* in all three areas of sciences were counted. Also counted were tea*cher* responses of *Very Well Prepared* in two areas and *Fairly Well Prepared* in the third area of science.
Perceptions of Preparedness to Teach Diverse Learners	Teachers feel prepared to teach diverse learners in science	When the majority of teachers at each school reported a composite score greater than the National Mean (53.5) they were counted.
Perceptions of Preparedness to Encourage Students	Teachers feel prepared to encourage students in science	When the majority of teachers at each school reported a composite score greater than the National Mean (65.9) they were counted.

In regards to teacher development, only 25 teachers reported attending science-related professional development in the last three years. Of these 25 teachers that have attended professional development in science, only eight of them (from five schools) reported participating in at least two of the activities listed in Question 3.23 of the teacher survey. Six out of the 20 participant schools (20%) have teachers that feel *very well prepared* to teach all the sciences and have teachers that accessed high-quality professional development. There are only two schools out of the 20 that are providing both high-quality science professional development or science-focused professional development and have teachers with strong backgrounds in science content, working with diverse learners, and feel prepared to encourage students in science (see Table 57). These two schools are both low-SES schools and are located within two separate regions of Idaho.

Table 57. Teacher Beliefs about Access to Professional Development in Science and Feelings of Preparedness, as Primary Indicators of teacher Background and Development

School	Access to science-focused professional development	Access to high-quality science professional development	Teachers feel prepared to teach life, earth, and physical science content	Teachers feel prepared to teach diverse learners in science	Teachers feel prepared to encourage students in science
Hydrogen Elementary		Present			
Helium Elementary	Present			Present	
Beryllium Elementary					Present
Boron Elementary				Present	Present
Carbon Elementary			Present		Present
Nitrogen Elementary	Present	Present	Present	Present	Present
Oxygen Elementary	Present	Present	Present		Present
Fluorine Elementary					Present
Neon Elementary			Present		Present
Sodium Elementary	Present			Present	Present
Magnesium					

Elementary					
Aluminum Elementary	Present	Present			
Silicon Elementary					Present
Phosphorus Elementary					Present
Sulfur Elementary				Present	Present
Argon Elementary	Present		Present	Present	Present
Potassium Elementary	Present		Present	Present	Present
Calcium Elementary		Present			

Question 2: Sub-question on Teacher Background and Development

Question 2 focused on the differences between low and high-SES schools. The sub-question for Teacher Background and Development asked, “Is there a difference in the implementation of Teacher Background and Development between Idaho low and high-SES, high science achieving elementary schools?” I found very little difference between the high and low-SES teachers. A larger number of high-SES teachers reported the presence of a STEM initiative within their school or district within the last five years than low-SES teachers ($p = 0.01$). This may indicate that high-SES teachers have easier access to professional development than the low-SES school teachers.

I will now turn my focus to a discussion of the teacher and principal survey results regarding the key element Instructional Leadership and Mandate.

Instructional Leadership and Mandate

Instructional leadership encompasses all actions performed or delegated by a leader for the purpose of supporting teachers' development and promoting student growth in science. This instructional leadership in science should extend from positional leaders to shared leadership roles within the school (DeBevoise, 1984; Spillane et al., 2001; Inverness Research Associates, 2006b, 2007; Casey et al., 2012). Instructional mandate is the requirement of a school and its teachers to implement science instruction, encompassing the quality of instruction and the quantity of instruction (Inverness Research Associates, 2006a, 2006b, 2007; St. John et al., 2007)

Using data from the teacher and principal surveys, I looked for evidence to support the presence of Instructional Leadership and Mandate in the entire sample, and within the sub-populations. To analyze Instructional Leadership and Mandate, I looked for evidence of teachers taking on science-related leadership roles and evidence of strong instructional leadership by the building principals. As part of instructional leadership, I was interested in identifying the presence of a mandate for science instruction, support for science learning communities, presence of science instructional observation, and support for struggling science teachers. I evaluated the total principal and teacher samples, looking for evidence of the entire Idaho sample meeting the Instructional Leadership and Mandate criteria. I then evaluated the low-SES schools and high-SES schools' samples on the same Instructional Leadership and Mandate criteria to determine if both sub-populations met the criteria for Instructional Leadership and Mandate separately.

Teachers as Leaders

Much research has found teachers often play an integral role in elementary science reform implementation through shared leadership roles (Heenan & Helms, 2013; Inverness Research Associates, 2006b; St.John et al., 2007; Spillane et al., 2001). These roles may include teacher leaders, content or kit specialists, and mentors or coaches. These roles may be officially contracted designations; they may have no official designations or receive monetary resources, release time, or reduction in teaching responsibilities. When I assessed the Idaho high science achieving schools for the presence of teacher leadership, the evidence was mixed. At the classroom level, teachers reported that they were only *sometimes* given the opportunity to: play a role in school-wide decision making; have significant input into plans for professional development; and influence school decisions as a team. Only 5% of teachers reported that they had provided mentoring to other teachers in science. Five percent of the teachers also reported that they had lead teacher in-service workshops on science or science teaching. When I matched teachers across items in Questions 5.4 and 5.2 on the teacher survey, I found only one participant teacher that participated in a leadership role at the school level and at the classroom level as a mentor or coach. At the school level, 65% of participant principals reported that their school received funding for science from teacher-initiated grants, indicating that teachers took on leadership roles in their schools. I did not find a significant difference in teacher leadership between the low and high-SES schools.

Mandate

I assessed the schools for the presence of a mandated science instruction within each of the participant schools. I found that seven of the 20 schools that participated in both the principal and teacher surveys provided evidence of a scheduled, mandated, science instruction time present in their schools (see Table 55). Other participant schools might have had science instruction mandated in the form of the principals telling the teachers that they need to teach science. Principals in other schools may have even provided a suggested length of time per week to instruct students in science. However, only 30% of the schools reported lengths of instructional time and frequency of science instruction that matched when I compared the principal and teacher responses from the same schools.

Science is viewed as a core subject in the elementary school. However, it is not assessed to the degree that reading, language arts, and mathematics are assessed. In Idaho, the science ISAT is given in fifth, seventh, and tenth grades, meeting the standard set by No Child Left Behind (NCLB). There are some indications that this pattern of assessment causes science to continue to be one of the most disregarded subjects at the elementary level. Research has found that science is regarded as a fringe subject that is accessed when time allows, taught intermittently and unsystematically (Ediger, 1999; Greenleaf, 1982; Mechling & Oliver, 1982, 1983; Spillane et al., 2001; Vasquez, 2005). Of the Idaho high science achieving schools, teachers from 30% of the schools stated that their schools placed a priority on science in fourth and fifth grades because it was tested in the fifth grade. Teachers from 15% of the participant schools reported that prior to giving the fifth grade science ISAT, they participated in a considerable amount of drilling of the standards with their students. This haphazard treatment of elementary science instruction is counterproductive in developing a foundation for intellectual development, scientific literacy, and STEM career awareness. The fact that some schools that participated in this type of haphazard treatment of science have been identified by the science ISAT as high achieving schools should bring question to the quality of the science ISAT as an indicator of high science achievement. The science ISAT may have indicated the schools that are able to prepare their students well to answer recall questions, but it is not able to distinguish quality of thought and depth of understanding. This is not surprising since the fifth grade ISAT is primarily composed of recall questions (Depth of Knowledge - Level 1) and contains no extended thinking questions (Depth of Knowledge - Level 4) (NCES, 2011).

Principals as Instructional Leaders, Observation and Feedback

Teachers need principals’ support to remodel their instructional practices (Banilower et al., 2013; Johnson & The Project on The Next Generation of Teachers, 2007). Research indicates that principal support increases teachers’ efficacy, positively impacts instructional practices, increases implementation of reform-based instructional practices, and promotes student achievement (Pitner, 1988; Hallinger & Heck, 1998; Blasé & Blasé, 1999a, 1999b; Banilower et al., 2006).

At the classroom level, Idaho high science achieving school teachers indicated that principal support is important in promoting effective instruction. However, only 13% of the surveyed low-SES teachers reported that their principal had observed them teaching science during a formal observation. High-SES principals did significantly better. Seventy-seven percent of high-SES high science achieving school teachers indicated that their principals observed them during a formal observation teaching science. Similarly, only 23% of participant low-SES teachers received feedback from their principal on their science instruction, and even fewer, 13%, received specific feedback on reform-minded science instruction from their principal. This was compared to 62% of high-SES teacher participants having received feedback on their science instruction, and 23% receiving feedback that was focused on reform-minded science practices.

A much larger percentage of teachers (70%) indicated that they had been observed during an informal observation or walk-through observation. This finding on informal observations was not significantly different between low and high-SES teacher participants. However, the median number of times that teachers had been observed was only 1 (0, 2) occurrence during an informal observation, as opposed to the median for formal observations, 0 (0, 1) occurrences for low-SES teachers and 1(0, 2) times for high-SES teachers. I matched data from the teacher survey and the principal survey and found that in three out of 20 participant schools (15%), principals are providing reform-oriented observation and feedback on science instruction. Teachers received observation and general instructional feedback on their science teaching, in an additional three out of the 20 schools. In total, science instructional observation and some kind of instructional feedback on that instruction is occurring in six out of the 20 participant schools (30%) (see Table 58).

These data indicated that even in high science achieving schools, there was not strong support for developing high-quality reform-minded science instruction. I found a significant difference between the low and high-SES schools in the percentage of teachers reporting they were observed teaching science during a formal observation (the percentage of teachers reporting feedback on science instruction) and the median amount of times that teachers were observed during formal science instruction. These differences in principal observations were consistent with the research that has indicated principal support positively impacts instructional practices and increases implementation of reform-based instructional practices (Pitner, 1988; Hallinger & Heck, 1998; Blasé & Blasé, 1999a, 1999b; Banilower et al., 2006).

Support for Struggling Teachers in Science

When low and high-SES school principals were asked at the school level about the support structure they had in place for struggling teachers in science, the largest number of principals (41%) reported providing higher levels of supervision and guidance from a formally designated mentor or coach to teachers struggling in science. Only 14% of principals encouraged these teachers to attend seminars, classes, or study groups to improve their instruction. I found no significant difference between high and low-SES principals ($p>0.05$).

Science Mentors and Coaches

A mentor or coach who models high-quality science instruction provides mentees with a full understanding of how to teach science. There is a difference between modeling science instruction, and modeling high-quality science instruction. Hudson (2005) found that most teachers do not receive experienced mentors or coaches that model high-quality instruction in the field of elementary science education. However, the in-school context of receiving high-quality mentoring and coaching is pivotal in their development as teachers (Hudson, 2005). Since this study is based on self-report survey data, it is unknown the quality of coaching and mentorship that was provided within the various high science achieving schools.

What the data did indicate, however, was that there was a significant difference in the low and high-SES school teachers who reported having received feedback about their teaching from a mentor or coach formally assigned by their school or district ($x^2(1) = 7.66$, $p = 0.01$). Sixteen percent of the low-SES school teachers reported that they had received feedback from a formally assigned mentor or coach, in contrast 58% of high-SES teachers reported that they had received feedback from a formally assigned mentor or coach. When teachers were asked about mentorship and coaching, few respondents indicated that these roles existed in their schools or districts. A small percentage of teachers indicated that their principal (2%), district science supervisor or coordinator (7%), teachers who have no classroom teaching responsibilities in the district (5%), and teachers with full-time teaching responsibilities in the district (12%), filled coaching or mentoring roles in their district. These findings were similar to what the principals reported, except that the principals reported that 23% saw themselves as filling this mentoring or coaching role in their school. Five percent of the high science achieving school teachers reported that they had served as a formally-assigned mentor or coach for science teaching and 33% reported that they had supervised a student teacher in their classroom. I found no additional significant differences in responses from teachers or principals, from low and high-SES schools ($p>0.05$).

Science Professional Learning Communities

St. John et al. (2007) and Heenan & Helms (2013) found that districts were able to build capacity for science reform through the use of lesson study. Twenty-six percent of participant principals reported that in the last 5 years, their school offered teachers study groups where teachers met on a regular basis to discuss teaching and learning of science. During these study groups, principals indicated that teachers primarily planned science lessons together, analyzed students' science assessment results, and analyzed science instructional materials. Zero percent of the teacher sample reported that they had led a professional learning community, lesson study, or teacher study group focused on science or science teaching. When teachers were asked about participation in professional learning communities, lesson study, or teacher study groups focused on science or science teaching, 50% reported that they had participated in one of these types of learning communities within the last three years. I found no significant difference between low and high-SES school principals ($p > 0.05$).

Question 1: Sub-question on Instructional Leadership and Mandate

Analysis of the teacher and principal survey results provided insight into the Instructional Leadership and Mandate key element within high science achieving elementary schools in Idaho. The Instructional Leadership and Mandate sub-question I asked was, "Is there evidence that all of the participant Idaho high science achieving schools are activating the key element Instructional Leadership and Mandate?" The answer to this question is no; the evidence does not support all of the Idaho high science achieving schools having strong instructional leadership support for science or a mandate for science instruction. To quantify the presence of the key element Instructional Leadership and Mandate, I chose five primary indicator items. These primary indicators came from teacher survey items, principal survey items, and one-question composites. These primary indicator items and the methods used to indicate the presence of the primary indicators are presented in Table 58.

Table 58. Instructional Leadership and Mandate Primary Indicator Items and Criteria for Indicating their Presence

Question Number(s)	Primary Indicator	Criteria for Indicating Items Presence
Teacher Survey Q5.5_1,2	Observation of Science Lessons	The mean teachers' responses from a given school of *Yes* to either of the questions, 5.5_1 or 5.5_2 were counted. These responses were cross-referenced with the principal survey responses and were found to similar.
Teacher Survey Q5.5_3,4	Instructional Feedback	The mean teachers' responses from a given school of *Yes* to either of the questions, 5.5_3 or 5.5_4 were counted.
Extent to Which Policy Environment Promotes Effective Instruction	Policy Environment Promotes Science	When the majority of teachers at each school reported a composite score greater than the National Mean (65) they were counted.
Teacher Survey Q5.7_4,5,6	Science Feedback from Instructional Coach	The mean teachers' responses from a given school of *Yes* to any of the question 5.7_4, 5, or 6 were counted.
Teachers Survey 2.7 and Principal survey 3.2	Mandate for Science Instruction	Schools were counted as having mandate presents, when agreement existed between teacher and principal responses regarding the frequency of science instruction within their school.

Thirteen out of 20 schools had some aspect of instructional leadership or mandate present in their schools. However, only three of the 20 participant schools had strong instructional leadership, providing evidence for the presence of four of the five primary areas of instructional leadership (see Table 59). Shared leadership is also present within the Idaho high science achieving schools, but to a very limited extent. The three schools providing strong instructional leadership represent one low-SES school and two high-SES schools, and are located within two regions of Idaho.

Table 59. Principal and Teacher Agreement on the Presence of Observation, Feedback, and Mandate in their School, as Primary Indicators of Instructional Leadership and Mandate

Schools	Observation of Science Lessons	Instructional Feedback	Science Feedback from Instructional an Coach	Policy Environment Promotes Science	Mandate for Science Instruction
Helium Elementary	Present				Present
Lithium Elementary		Present		Present	
Beryllium Elementary		Present	Present	Present	
Carbon Elementary				Present	Present
Oxygen Elementary	Present	Present		Present	Present
Neon Elementary	Present	Present	Present		Present
Sodium Elementary	Present		Present		
Magnesium Elementary	Present	Present		Present	
Aluminum Elementary	Present	Present	Present	Present	Present
Silicon Elementary	Present	Present			
Sulfur Elementary			Present		Present
Chlorine Elementary	Present	Present		Present	
Argon Elementary			Present		Present

Question 2: Sub-question on Instructional Leadership and Mandate

Question 2 focused on the difference between low and high-SES schools. Question 2 sub-question on Instructional Leadership and Mandate asked, “Is there a difference in the implementation of Instructional Leadership and Mandate between Idaho low and high-SES, high science achieving elementary schools?” There appears to be a greater amount of instructional leadership in science within the high-SES schools, as reported by the teachers. There was more observation, more instructional feedback, and more coaching and mentoring occurring in the high-SES schools, within the context of science instruction. I found no evidence that these differences were due or not due to capital or social pressures. Research indicates that reform-based science instruction is more easily implemented within a school when there is strong instructional leadership that supports reform-based science instruction. It is interesting to note that more high-SES teachers reported instructional observation and feedback on their science instruction, and more high-SES teachers reported a greater frequency of using hands-on/laboratory activities.

I will now turn my focus to a discussion of the teacher and principal survey results regarding the Assessment and Feedback key element.

Assessment and Feedback

Assessments are a method of establishing evidence of students’ ability to use scientific practices, apply their understanding of crosscutting concepts, and draw on their understanding of specific disciplinary ideas, over time (Pellegrino et al., 2014). Student assessment should come from a variety of approaches, including: diagnostic, formative, summative, and performance. Data collected from these assessments provides continuous feedback on teachers' instructional effectiveness, their students' learning, and should be used to make data driven decisions about refinement of curriculum and instructional practices (Inverness Research Associates, 2007; Pellegrino et al., 2014).

I looked for evidence to support the presence of Assessment and Feedback in the entire sample, and within the sub-population, by using data from the teacher and principal survey. To analyze Assessment and Feedback, I looked for evidence of the types of classroom assessment teachers implemented, how they assessed data to drive instructional practices, the methods teachers used to monitor student progress, and the support systems they used to help struggling students. I was also interested in identifying if science was monitored school wide. I first evaluated the total principal and teacher samples looking for evidence of the entire Idaho sample meeting the Assessment and Feedback criteria. I then evaluated the low-SES schools' and high-SES schools' samples on the Assessment and Feedback criteria to determine if both sub-populations met the criteria for Assessment and Feedback separately.

Classroom Assessment

Based on large body of research, Pellegrino et al. (2014) concluded that assessment, consistent with high-quality instruction in science, needs to balance three dimensions of learning. These three dimensions include: students' ability to apply scientific practice, students' understanding of crosscutting principles, and students' understanding of specific disciplinary ideas (Black & Wiliam, 2009; Heritage, 2010; Perie et al., 2007; NRC, 1998, 2012; NGSS Lead States, 2013; Pellegrino et al., 2014). Pellegrino et al. (2014) also believed that scaffolding of the three dimensions needs to occur over time to take into account developmental appropriateness. There is no single form of assessment that is capable of assessing all three dimensions of learning simultaneously (Pellegrino et al., 2014). For this reason, teachers need to implement a variety of assessment activities and approaches, including diagnostic, formative, summative, and performance. These assessment tasks must represent: what is valued; the curriculum objectives; the instructional methods; and the purpose for the assessment (Hanna & Dettmer, 2004).

Diagnostic assessments were reportedly used by 63% of the participant teacher sample. Fifty percent of principals reported that diagnostic assessments were used in their schools. When principal and teacher results were compared at the school level, diagnostic assessments were happening in six out of the 20 participant schools (30%). These schools represent three low-SES and three high-SES schools. I found no significant difference between the low and the high-SES school teachers ($p > 0.05$).

Formative assessment implemented both formally and informally for the purpose of learning to evaluate key points and check for student understanding before, during, and after instruction was reportedly used by 80% of the teacher sample. Principals’ reporting of teachers’ use of formative assessment was consistent with teachers’ self-reporting. When teachers were asked more specifically, about some forms of formative assessment, I found that 46% of the teachers reported using student self-assessments, compared to 55% of principals who believed that this method of assessment was used in their school. Thirty-three percent of teachers reported that they had their students use rubrics to assess other classmates’ work. Over 90% of teachers reported using various forms of informal assessments to evaluate if their students were understanding the material. These informal assessments included questioning, reviewing students’ work, and informal observations. I found no significant difference in these findings between low and high-SES school teachers ($p < 0.05$).

Summative assessments used to evaluate students' learning were reportedly used by 79% of the participant sample. Principals reporting of teachers' use of summative assessment was consistent with teachers' self-reporting. Additionally, 83% of the teachers reported that their assessments were aligned with the Idaho state standards. I found no significant difference between the low and the high-SES school teachers ($p > 0.05$).

Performance assessment, also known as authentic assessment or assessment tasks, were reportedly used by 88% of the teacher sample. I found no significant difference between the low and the high-SES school teachers ($p > 0.05$). I found that 76% of the teachers reported using science notebooks with their students, however only 5% of principals believed that their teachers used science notebooks as a form of assessment.

In order for teachers to assess students on all three dimensions of learning, they should use a variety of assessment activities, providing tasks with multiple components, focusing on connections among scientific concepts, and gathering information about how far students have progressed along a defined sequence of learning (Pellegrino et al., 2014). It is not possible to ascertain from the study to what degree each type of assessment was implemented, but what I was able to determine was that formative, summative, and performance assessments were reportedly used by approximately 80% of sampled teachers. When I compared the principal and teacher data, I found that seven of the 20 participant schools (35%) were implementing all three of these assessment types in science (see Table 57). I also found that 11 of the 20 participant schools (60%) were implementing the use of science journals (see Table 57). Both of these findings were split evenly between low and high-SES school.

Data Driven Instructional Practices

The majority of teacher responses indicated that they do use assessments to remodel their instructional practices; see Table 43. This was found across low and high-SES schools, with the exception of participation in the re-evaluation of textbooks and learning materials as a result of student assessments. I found a significant difference between low and high-SES schools' teacher response on this item ($p = 0.03$), with low-SES school teachers more likely to re-evaluate curriculum materials based on assessment results, than high-SES teachers. The majority of principals also indicated that their teachers implemented remodeling of their instruction due to assessment results. I found no significant differences between low and high-SES school principals.

School-Wide Monitoring of Student Progress in Science

At the school level, principals need to model use of both summative and formative assessment data to monitor progress and direct curriculum decisions within their schools (DuFour et al., 2006). Sixty-four percent of principals reported that they do monitor student progress in science. I found no significant difference between principals from low and high-SES schools.

When teachers were asked if their principals monitored student achievement in science at the school level, only 36% of teachers reported their principals made an effort to monitor student progress in science. I found no significant difference between teachers from low and high-SES schools. Evidence teachers provided of their principals monitoring progress in science most commonly included monitoring of ISAT results and student report cards. Other examples that teachers provided included: monitoring of grade-level assessment content; support of science fairs; interactions with students during observations of science lessons; and monitoring of objectives during classroom visits.

Question 1: Sub-question on Assessment and Feedback

Analysis of the teacher and principal survey results provided insight into the Assessment and Feedback key element within high science achieving elementary schools in Idaho. The Assessment and Feedback sub-question I asked was, “Is there evidence that all of the participant Idaho high science achieving schools are activating the key element Assessment and Feedback?” The answer to this question is no; the evidence does not support all of the Idaho high science achieving schools providing a full scope of assessment to allow for a balance assessment of all three dimensions of learning. To quantify the presence of the key element Assessment and Feedback, I chose two primary indicator items. These primary indicators came from teacher survey items. These primary indicator items and the methods used to indicate the presence of the primary indicators are presented in Table 60.

Table 60. Assessment and Feedback Primary Indicator Items and Criteria for Indicating their Presence

Question Number(s)	Primary Indicator	Criteria for Indicating Items Presence
Teacher Survey Q6.2_1,2,3,4	Use of Formative, Summative, and Performance Testing	The mean teachers’ responses from a given school of *Yes* to all of the questions, 5.2_1, 2,3, and 4 were counted. These responses were cross-referenced with the Principal survey, but consistency was not observed.
Teacher Survey Q6.2_5	Use of Notebooks	The mean teachers’ responses from a given school of *Yes* were counted. These responses were cross-referenced with the Principal survey, but consistency was not observed.

Seven out of the 20 participant schools (40%) reported providing a comprehensive evaluation of science through the use of formative, summative, and performance evaluations and also employ the use of science notebooks (see Table 61). These schools represent five low-SES schools and one high-SES school. They are located within four separate regions of Idaho.

Table 61. Presence of Formative, Summative, and Performance Testing in Science and use of Science Journals in Science, as Primary Indicators of Assessment and Feedback

Schools	Use of Formative, Summative, and Performance Testing	Use of Notebooks
Beryllium Elementary	Present	Present
Boron Elementary	Present	Present
Nitrogen Elementary		Present
Oxygen Elementary		Present
Neon Elementary		Present
Sodium Elementary	Present	Present
Magnesium Elementary		Present
Silicon Elementary	Present	Present
Phosphorous Elementary	Present	Present
Sulfur Elementary	Present	
Chlorine Elementary	Present	Present
Argon Elementary	Present	Present

Question 2: Sub-question on Assessment and Feedback

Question 2 focused on the difference between low and high-SES schools. Question 2 sub-question on Assessment and Feedback asked, “Is there a difference in the implementation of Assessment and Feedback between Idaho low and high-SES, high science achieving elementary schools?” The only significant difference that I found in Assessment and Feedback between the low and high-SES teacher responses was on the re-evaluation of textbooks and learning materials based on whole-class assessments (p = 0.03). A larger percentage (75%) of low-SES school teachers said that they would re-evaluate textbooks and learning materials based on whole-class assessments, compared to only 33% of high-SES teachers. I found little difference between the low and high-SES schools in the area of Assessment and Feedback.

Summary

Question 1 asked if any of the key elements to elementary science reform were present within all of Idaho high science achieving elementary schools. This question was further broken into four sub-questions, related to each of the key elements, which asked if all the schools were activating each of the key elements individually. Hypothesis 1 stated that evidence of each of the four elements would be found within all the high science achieving schools. The collected evidence indicated that all four elements were not present in all 20 participating schools. To quantify the presence of the key elements, I used primary indicator items. The criteria that I used to determine if enough primary indicators items were present for each of the key elements for that key element to be considered present can be found in Table 62.

Table 62. Criteria for Determining the Presence of each of the Key Elements

Key Element	Criteria
Program and Practice	At least five primary indicators must be rated present, with at least one in the area of curriculum and one in the area of equipment and facilities.
Teacher Background and Development	At least four of the primary indicators must be rated present.
Instructional Leadership and Mandate	At least four of the primary indicators must be present.
Assessment and Feedback	Both primary indicator items are present.

Further analysis of the data, provided by the use of the primary indicator items, showed that fourteen of the 20 participating schools (70%) have evidence of at least one of the key elements. Of these fourteen, nine schools (45%) had evidence of two of the key elements and one had evidence of three elements (5%) (see Table 63). The mean science ISAT score for these fourteen schools on the 2013 science ISAT was 215, which is one point below *Advanced*. These schools are located within four separate regions of Idaho, representing eight low-SES schools and six high-SES schools.

Table 63. Summary of Presence of the Key Elements found in Participating Schools

School	Program and Practice	Teacher Background and Development	Instructional Leadership	Assessment and Feedback
Beryllium Elementary	Present			Present
Boron Elementary	Present			Present
Carbon Elementary	Present			
Oxygen Elementary	Present	Present	Present	
Fluorine Elementary	Present			
Neon Elementary	Present		Present	
Sodium Elementary	Present			Present
Magnesium Elementary	Present			
Aluminum Elementary		Present	Present	
Silicon Elementary				Present
Phosphorous Elementary				Present
Chlorine Elementary				Present
Argon Elementary		Present		Present
Potassium Elementary		Present		

Question 2 asked if the implementation of key elements to elementary science reform differed between the low and high-SES high science achieving schools in Idaho. This question was further broken into four sub-questions, related to each of the key elements. Hypothesis 2 stated that based on the different pressures present in low and high-SES schools, the implementation level for each of the key elements in high and low-SES schools relates to high achievement would differ.

I found that high-SES schools did have greater instructional leadership from their principals, through increased observation and feedback to their teachers. Similarly, high-SES teachers reported less control over the science curriculum than was reported by the low-SES school teachers. High-SES teachers reported a higher frequency of implementing reform-based science instructional practices, and specifically reported a higher frequency of hands-on/laboratory-based activities. High-SES schools also reported greater financial support from parents for science instruction. Even with these differences, surprisingly, little else was different between the low and high-SES schools. Both low and high-SES school teachers felt ill prepared to implement physical science or engineering instruction. Principals from both low and high-SES schools reported small science budgets, and teachers reported very little access to science-related instructional and resource supports. It is possible that the small differences that I saw reported between the low and high-SES schools were due to differences in pressures. For example, high-SES principals may have more time to budget towards focusing on the quality of science instruction occurring in their school, because they did not need to budget as much time towards factors facing principals in the low-SES schools. There was also evidence of budgetary pressures reported by the principals. Although minimal, there was evidence of differences in pressure present between the low and high-SES schools. For this reason my hypothesis was supported, differences did exist in the pressures present between high and low-SES schools.

Limitations

Limitations of this study include the lack of observational matched data to compare to the survey data. The results of this study are reliant on principals and teachers providing accurate self-report data. The study size was limited by the population of the state and the limited number of individuals that conformed to the sample demographics. However, these same limitations made this study something that could fit within the scope of a dissertation, where as in a more populated state I would have had to narrow the scope of the study considerably. Access to statewide assessment data was another limitation, since the only universally given science assessment in Idaho is the science ISAT, which is only given one time a year in the fifth grade. Each state has developed their state-level science assessment independently, limiting the generalizability of this study outside of the state of Idaho.

Conclusion

Elementary science education is important for building a foundation for intellectual development and scientific literacy, and providing an entry point into interest in Science, Technology, Engineering, and Mathematics (STEM) fields (Allen, 2006; AAAS, 1993b, 2009; Furtado, 2010; Keeves, 1995; Michaels et al., 2008; NRC, 2007). Nationally, a goal to increasing the number of students entering STEM careers exists. If Idaho shares in this goal, it is necessary for Idaho schools to make elementary science a greater priority. The results of this study indicate that Idaho may have advantages over other states in achieving this goal. Studies conducted in other states have indicated that SES is a barrier to science achievement. This study shows that SES may only be a minor hindrance to science achievement in Idaho. For this reason, it is a feasible goal to provide all students with high-quality elementary science instruction. However, to reach this goal, it will be necessary for Idaho schools to make elementary science a greater priority.

Inverness Research Associates concluded, based on 25 years of experience researching and evaluating school systems going through elementary science reform, that four key elements are necessity to create and sustain an environment in which elementary science reform can take hold and become sustainable. This study builds on the understanding of these four key elements as important in developing high-quality science education programs. Where Inverness Research Associates have looked at programs that are purposefully targeting elementary science reform with large grants from the National Science Foundation, this research looked at existing programs across the state of Idaho in which the science ISAT results have identified them as high achieving in elementary science, scoring them as *Advanced* or within the top third of *Proficient*. The purpose of this research was to identify if all four of the key elements to elementary science reform were present in programs considered high-achieving programs within Idaho. In addition, this study also sought to identify if there were differences in the presence of the key elements within low and high-SES elementary schools in Idaho. One key assumption of this study was that the science ISAT is capable of detecting and identifying the presence of high-quality science instruction. The other assumption is that the key elements are indeed necessary in achieving high-quality science instruction.

I found the key elements present in the Idaho high science achieving schools. However, I did not find them to the same extent found in the schools where Inverness Research Associates conducted their research and evaluated NSF funded elementary science reform initiatives. The science ISAT identified schools who displayed up to three of the key elements. However, the science ISAT also identified schools that were not activating any of the key elements and lacked the characteristics of schools engaged in high-quality science instruction.

Surprisingly, the high science achieving schools in Idaho did not spend more time on science instruction than what was found in 2009, when fourth grade teachers were surveyed by the NAEP. This is worth noting, for several reasons. It tells us that quality instruction may be more important than quantity of instruction. This is important for time strapped schools. This finding is also interesting when you consider that both the principal and teacher survey data revealed a distinct ‘ramp-up’ of science instruction, creating a distinctive increase in time spent on science during the fifth grade year, presumably in an effort to prepare students for the fifth grade ISAT. Since the majority of my sample was composed of fifth grade teachers, I expected to see more time dedicated to science instruction than what was found statewide, when fourth grade teachers were surveyed by the NAEP. Instead, I found that there was very little difference between the time spent on science reported by the NAEP and the time spent reported by teachers in this study. The two hours per week reported by both of these studies are one of the lowest reported times spent on science in the nation. The NAEP found that as schools spent more time on science, their students’ test scores rose, with the highest performing schools spending 3–4 hours per week on science. This is another reason I was surprised to find that the high-achieving elementary science schools in Idaho schools were not spending more time on science. This finding is not specific to either the low-SES or high-SES schools nor is the way that the low and high-SES schools budget their day to the various subject areas. This finding underscores the importance of quality instruction. If schools are to raise the achievement bar on science, quality instruction cannot be overlooked. Since multiple key elements were found in several of the high science achieving elementary schools, indicating that high-quality instruction is likely taking place, it appears that these Idaho schools may be packaging high-quality science instruction into a more compact timeframe.

Idaho high science achieving teachers appear to have stronger content and pedagogical backgrounds in science education, as well as greater access to science professional development than what was found in the national data (Banilower et al., 2013). However, the support they receive for science instruction is not overwhelming. This increased background knowledge may be helping the high science achieving elementary schools to overcome their lack of support for science. This background, however, it is not enough to make teachers feel well prepared in the physical sciences or engineering, or in teaching diverse learners and encouraging their students in science. Teachers need more professional development on working with diverse learners in science and focused professional development on the physical sciences and engineering. Most importantly, though, teachers need the support of their principal.

School principals have the greatest influence within the context of the school because they have the authority to influence access to resources (Ediger, 1999; Greenleaf, 1982; Mechling & Oliver, 1982, 1983; Vasquez, 2005). The majority of principals were teachers first. Few of the sampled principals were secondary science teachers, which may indicate that many of them may feel similarly ill prepared to teach and coach teachers on high-quality science instruction. Additionally, few principals admitted observing or providing science reform-based feedback to their classroom teachers in science. As we ask teachers to implement more high-quality reform-based science instruction, it is imperative that we build a system of support to encourage reform-based instruction. Many of the reform schools observed by Inverness Research Associates (Heenan & Helms, 2013; Inverness Research Associates, 2006a, 2006b; St. John et al., 2007, 2008), designated science specialists to provide coaching and mentoring in the elementary grades. This brings up an interesting point of discussion regarding elementary science specialist teachers. I found that the specialist teachers in Idaho had a deeper science-specific background and expressed greater feelings of preparedness in science, in addition they received regular feedback and observation of their instruction because science is all they teach. The schools where specialists were present also tended to have dedicated science facilities and resources for science.

Although both low and high-SES teachers report feeling ill prepared in the sciences, they felt comfortable making judgments regarding the quality of instructional materials they were using to implement their science instruction. Teachers reported supplementing their assigned science curriculum when: they had a different activity that they felt worked better to support the science concept being taught (82%); they needed a supplemental activity to provide students with additional practice (83%); or because they needed a supplemental activity for students with different ability levels (88%). Teachers reported skipping lessons in the assigned curriculum because: *they had a better lesson*; *they lacked materials needed to implement the activity* (62%); or *the ideas addressed in the activity were not covered in their assigned pacing guide* (54%). These teachers' responses underscore the importance of providing teachers with a high-quality science curriculum and a deeper content knowledge in science and pedagogical understanding of high-quality science instruction. It is important that teachers are provided both high-quality materials and support for implementing high-quality science instruction, as well as accountability for the implementation of high-quality science instruction.

Research has indicated that reform-based science instruction is more easily implemented within a school when there is strong instructional leadership that supports high-quality science instruction. The results of this study supported this finding. The sub-population (high-SES) with a higher amount of instructional leadership, evidenced by a greater frequency of observation of science instruction and less teacher control over the science curriculum, had a higher frequency of hands-on/laboratory-based activities. It is unknown, however, the type and quality of hands-on/laboratory-based activities being implemented within the classrooms of these Idaho schools. The survey tools that currently exist do not extract enough information to ascertain teachers’ levels of understanding or their perceptions regarding high-quality science instructional strategies, such as the types of questioning strategies they use and how they scaffold their hands-on instruction to develop crosscutting science concepts and skills in their students.

It is apparent that even in the high science achieving elementary schools in Idaho, high-quality science instruction is not valued. This undervaluing of science education is apparent in the budgets reported for science and the time budgeted for science. Budgets for science resources necessary for providing high-quality science instruction are non-existent in many of the schools, and textbooks or science modules are outdated. Both low and high-SES schools need to be more realistic in the cost to implement high-quality science instruction. Teachers should not be relied on or expected to pay for materials to implement high-quality instruction. Budgetary support reflects what is valued. When the support for implementing high-quality science instruction is lacking, it sends a strong message that high-quality science instruction is not important. Instructional time for science is a fraction of the time spent on ELA and mathematics, and observation and reform-based feedback of science instruction is rare.

As an assessment tool, the science ISAT should measure what we value. If we value high-quality science instruction, it is possible that the science ISAT is a poor proxy for measuring science achievement. Although the science ISAT identified schools that were using high-quality reform-based science instruction, it also identified schools that used a fair amount of non-reform-based science instruction. Other states, like Washington, have moved towards a more performance-based approach where students are provided prompts with data tables and diagrams in which students have to interpret data, calculate responses, and construct well-written evidence-based responses. On the Washington Assessment of Student Learning (WASL) science test, 64-71% of the fifth grade questions push students' cognition skills into application, analysis, synthesis, and evaluation (Washington OSPI, 2004). Seventy percent of the WASL is composed of questions focusing on crosscutting concepts (systems, inquiry, and application) (Washington OSPI, 2013). This type of assessment is getting closer to what we value. The data that this study provides points us towards the conclusion that we are not measuring what we value with the science ISAT.

The results of this study provide good news for Idaho schools. Socioeconomic status is not a major hindrance to high achievement in science for Idaho elementary schools. If Idaho educators, administrators, and policy makers choose to make science a priority at the elementary level, high science achievement in elementary science is within reach for all Idaho schools.

Recommendations

This study supports the need for the presence of the key elements to create a supportive environment in which elementary science reform can take hold. The many elementary schools identified by the science ISAT as high science achieving schools had the key elements present in them. The ones that did not have key elements present had supporting evidence from the statistical analysis of the survey data, as well as from open-response items on the surveys. The science ISAT did identify high-quality science programs. However, it also identified programs in which high-quality science instruction was not taking place. The big take away from this study is the start of a roadmap for ways in which Idaho can support its classrooms and schools in achieving the national goal of increasing the number of students entering STEM careers, by providing a solid foundation for scientific literacy and problem solving at the elementary level.

The key elements needing the most development are instructional leadership and mandate, followed by teacher background and development. To increase instructional leadership capacity in elementary science, at the school level, principals need access to professional development in monitoring and coaching high-quality science instruction. Adoption of observation models and protocols that are consistent with and support high-quality instruction are necessary. At the school level, principals need to mandate science instruction, setting aside time during the week at each grade level when science instruction must take place. When principals schedule in mandated time for science instruction, they protect teaching time for science instruction and send a message that science instruction is important. When any district or state implements large-scale professional development in science, it needs to offer paired instructional development that guides principals in how to best support their teachers in implementing science reform models. At the school level, we learn a lot from the successful NSF projects evaluated by Inverness Research Associates (Heenan & Helms, 2013; Inverness Research Associates, 2006a, 2006b; St. John et al., 2007, 2008). Teachers need access to tiered professional development that first builds confidence through building content knowledge and pedagogy, then guides teachers in how to develop and expand lessons that are consistent with high-quality instruction. Teachers need access and support to take on leadership roles in elementary science. Development of lesson study groups that focus on science pedagogy are advantageous.

The key element that the largest number of schools activated was program and practice. However, only eleven of the 20 schools activated this element. There exists a tremendous amount of room for growth in this area among even the high science achieving elementary schools. Teachers need support in the form of time; providing a mandated schedule for when science should take place during the week is a step towards ensuring science teaching time for high-quality instruction is protected and valued. Budgetary investment to purchase consumables and replace equipment that becomes broken is vital to ensuring teachers have the materials they need to maintain a high-quality program. Goldsmith and Pasquale (2002) found that the lack of adequate resources for science instruction cannot only affect the quality of instruction, it can actually prevent instruction from occurring. Budgetary commitment to high-quality science instruction must come from the state, district, and building levels.

Although this study provides support for the key elements as indicators of high-quality elementary science programs and begins to pave a road to understanding science elementary education at the school and classroom level in Idaho, further research on elementary science education in Idaho needs to be conducted to validate this study's conclusions. This future research should include multiple field observations within the science ISAT identified high science achieving elementary schools in Idaho. These observations would provide a rich understanding of what is occurring within the science, ISAT-identified, high-achieving elementary schools in Idaho.

Continued research and development should occur to develop survey tools that provide a richer understanding of high-quality science education. The current survey tools do not provide a clear rating of the quality of hands-on or laboratory-based activities implemented within classrooms. The current tools only indicate if hands-on or laboratory-based instruction is taking place. These tools do not extract enough information to ascertain a teacher's level of understanding, or the teacher's perceptions regarding high-quality science instructional strategies, such as the types of questioning strategies the teacher uses and how the teacher scaffolds their hands-on instruction to develop crosscutting science concepts and skills in their students. Further work needs to be conducted to develop more rigorous survey tools that will provide deeper insight into a teacher's ability to support high-quality science instruction. Additionally, to provide additional validity to the current study, and provide a clearer picture of what is occurring within the classrooms, field observations need to be conducted within participant schools. These observations would provide a richer understanding of what is occurring within high-achieving elementary schools in Idaho, as identified by the science ISAT, and provide greater insight into how teachers interpret their own teaching.

At the state level, Idaho educators and policy makers should insist on the development of a rigorous tool for identifying what is valued in science education. Idaho educators and policy makers should continue to monitor the effectiveness of the science ISAT as an accurate measurement of what we value in science education. The data that this study provides points us towards the conclusion that the science ISAT may not be measuring what we value. Although the science ISAT successfully identified some schools that model many of the key elements, it also identified schools that did not have any of the key elements present.

This study provides insight into future research in elementary science education, as well as provides the beginnings of a roadmap for educators, administrators, and policy makers for improving elementary science education in Idaho.

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APPENDIX A

Tables

Table A1. Programs and Practices Question Composites

Question Composites	Survey Question	Tool	Answer Choices	Variable Level of Measurement
Adequacy of Resources for Instruction Composite	Science courses may benefit from availability of particular kinds of items or facilities. What is the availability of the following items in your school? • Equipment (microscopes, beakers, etc.) • Instructional technology (calculators, computers, tablets, probeware, etc.) • Consumable items (chemicals, living organisms, batteries, etc.) • Facilities (lab tables, electrical outlets, facets and sinks, etc.)	Teacher Survey	5-point from Not available to Adequate	Ordered Scale/ Ordinal
Curriculum Control Composite	Do you have control over each of the following aspects of science instruction in your class(es)? • Determining course goals and objectives. • Selection of textbooks/ modules. • Selecting content, topics, and skills to be taught.	Teacher Survey	5- point from No control to strong control	Ordered Scale/ Ordinal
Pedagogical Control Composite	Do you have control over each of the following aspects of science instruction in your class(es)? • Selecting teaching techniques. • Determining the amount of homework to be assigned. • Choosing criteria for grading student performance.	Teacher Survey	5- point from No control to strong control	Ordered Scale/ Ordinal
Reform-Oriented Instructional Objectives Composite	Think about your plans for your class for the entire year. By the end of the year, how much importance will you place on each of the following student objectives? • Understanding science concepts. • Learning science process skills. • Learning about real-life applications of science. • Increasing students' interest in science. • Preparing students for future study in science.	Teacher Survey	5-point Likert, Inhibits effective instruction to Very important in promoting science instruction	Ordered Scale/ Ordinal
Use of Instructional Technology Composite	Are the following items available for small group (4-5 students) work in your class? • Personal computers, including laptops. • Hand-held computers (tablets, PDAs, iPad Touch, iPad). • Internet access. • Probes for collecting data. • Calculators.	Teacher Survey	5-point Likert, Never to All or Almost all science classes	Ordered Scale/ Ordinal
Use of Reform-Oriented Teaching Practices in Science Composite	Think about your science instruction; identify how often you used each of the following practices in your science instruction? • Have students work in small groups. • Do hands-on/ laboratory activities. • Engage the class in project-based learning (PBL) activities. • Have students represent and/ or analyze data using tables, charts, or graphs. • Require students to supply evidence in support of their claims. • Have students write their reflections in class or for homework.	Teacher Survey	5-point Likert, Never to All or Almost all science classes.	Ordered Scale/ Ordinal

Table A2. Teacher Background and Development Question Composites

Question Composites	Survey Question	Tool	Answer Choices	Variable Level of Measurement
Quality of Professional Development Composite	Think about all of your science related professional development in the last three years, which of the following statements describes your experience? • You had opportunities to engage in science investigations. • You had opportunities to examine classroom artifacts. • You had opportunities to try out what you learned in your classroom and then talked about it as part of the professional development. • You worked closely with other science teachers from your school. • You worked closely with other science teachers who taught the same grade and/ or subject whether or not they were from your school. • The professional development was a waste of your time.	Teacher Survey	5-point Likert, Not at All to To a great Extent	Ordered Scale/ Ordinal
Extent to which PD/ Coursework Focused on Student-centered Instruction Composite	Consider all the opportunities to learn about science or the teaching of science in the last three years, how much importance was placed on each of the following? • Finding out what students think or already know about the key science ideas prior to instruction on those ideas. • Planning instruction so students at different levels of achievement can increase their understanding of the ideas taught in each activity. • Monitoring student understanding during science instruction. • Assessing student understanding at the conclusion of instruction on a topic.	Teacher Survey	5-point Likert, Not at All to To a great Extent	Ordered Scale/ Ordinal
Perception of Preparedness to Teach Diverse Learners Composite	How well prepared do you feel to implement each of the following in your science instruction? • Plan instruction so students at different levels of achievement can increase their understanding of the ideas targeted in each activity. • Teach science to students who have learning disabilities. • Teach science to students who have physical disabilities. • Teach science to English-language learners. • Provide enrichment experiences for gifted students	Teacher Survey	4-point Likert, Not Adequately Prepared to Very Well Prepared	Ordered Scale/ Ordinal
Perceptions of Preparedness to Encourage Students Composite	How well prepared do you feel to implement each of the following in your science instruction? • Encourage students' interests in science and/ or engineering. • Encourage participation of females in science and/ or engineering. • Encourage participation of racial or ethical minorities in science and/or engineering. • Encourage participation of students from low socioeconomic backgrounds in science and/ or engineering.	Teacher Survey	4-point Likert, Not Adequately Prepared to Very Well Prepared	Ordered Scale/ Ordinal

Table A3. Instructional Leadership and Mandate Question Composites

Question Composite	Survey Question	Tool	Answer Choices	Variable Level of Measurement
Extent to Which the Policy Environment Promotes Effective Instruction Composite	Please rate the following on their importance of influence on your science instruction. • Idaho Content Standards in Science • District Curriculum Frameworks • School/ District Pacing Guides • State science testing and accountability policies. • District testing and accountability policies. • Textbook/ module selection policies. • Teacher evaluation polices.	Teacher Survey	5-point Likert, Inhibits effective instruction to Very important in promoting science instruction	Ordered Scale/ Ordinal
Supportive Context for Science Instruction Composite	In your opinion, how great a problem is each of the following for science instruction in your school as a whole? • Inadequate science-related professional development opportunities. • Community attitudes towards science instruction. • Conflict between efforts to improve science instruction and other school and/or district initiatives. • How science instructional resources are managed.	Principal Survey	5-point Likert, Unimportant to Very Important	Ordered Scale/ Ordinal
Extent to which a Lack of Materials and Supplies is Problematic Composite	In your opinion, how great a problem is each of the following for science instruction in your school as a whole? • Lack of science facilities. • Inadequate funds for purchasing science equipment and supplies. • Inadequate supply of science textbooks/ modules. • Inadequate materials for individualized science instruction.	Principal Survey	5-point Likert, Unimportant to Very Important	Ordered Scale/ Ordinal
Extent to which a Lack of Time is Problematic Composite	In your opinion, how great a problem is each of the following for science instruction in your school as a whole? • Insufficient time to teach science. • Lack of opportunities for science teachers to share ideas. • Inadequate science-related professional development opportunities.	Principal Survey	5-point Likert, Unimportant to Very Important	Ordered Scale/ Ordinal

Table A4. Assessment and Feedback Question Composites

Question Composite	Survey Question	Tool	Answer Choices	Variable Level of Measurement
Assessment Composite (AKA: Perceptions of Preparedness to Implement Instruction in a Particular Unit Composite)	How well prepared did you feel to do each of the following as part of your instruction on this particular unit? • Anticipate difficulties that students may have with particular science ideas and procedures in this unit. • Find out what students thought or already knew about the key science ideas. • Implement the science textbook/ modules to be used during this unit. • Monitor student understanding during this unit. • Assess student understanding at the conclusion of this unit.	Teacher Survey	5-point Likert, Not Adequately Prepared to Very Well Prepared	Ordered Scale/ Ordinal

Table A5. Composite Questions used on the Teacher Survey developed by Horizon Research (2012c)

Variable	Question Composites	Alpha (Horizon Research, 2012c)	lpha
Teacher Background & Development	Quality of Professional Development	0.72	.64
Teacher Background & Development	Extent to Which Professional Development/Coursework Focused on Student-Centered Instruction	0.86	.89
Teacher Background & Development	Perceptions of Preparedness to Teach Diverse Learners	0.80	.87
Teacher Background & Development	Perceptions of Preparedness to Encourage Students	0.92	.96
Assessment & Feedback	Assessment Composite (AKA: Perceptions of Preparedness to Implement Instruction in Particular Unit)	0.88	.88
Program & Practice	Adequacy of Resources	0.84	.76
Programs & Practice	Curriculum Control	0.80	.81
Programs & Practice	Pedagogical Control	0.73	.57
Programs & Practice	Reform-Oriented Instructional Objectives	0.72	.86
Programs & Practice	Use of Reform-Oriented Teaching Practice: Science	0.72	.83
Programs & Practice	Use of Instructional Technology	0.70	.50
Instructional Leadership & Mandate	Extent to Which the Policy Environment Promotes Effective Instruction	0.88	.79

Table A6. Questions Matched Principal-Teacher Perspective Questions

Principal Survey Question	Teacher Survey Question
Indicate whether each of the following programs and/or practices is currently being implemented in your school: a) Students not in self-contained classes and receive science instruction from a science teacher. b) Students in self-contained classes receive science instruction from a science specialist instead of their regular teacher. c) Students in self-contained classes receive science instruction from a science specialist in addition to their regular teacher. d) Students in self-contained classes receive science instruction from their regular classroom teacher only. e) Students in self-contained classes pulled out for remedial instruction in science. f) Students in self-contained classes pulled out for enrichment in science. g) Students in self-contained classes pulled out from science instruction for additional instruction in other content areas.	Indicate whether each of the following programs and/or practices is currently being implemented in your school: a) Students not in self-contained classes and receive science instruction from a science teacher. b) Students in self-contained classes receive science instruction from a science specialist instead of their regular teacher. c) Students in self-contained classes receive science instruction from a science specialist in addition to their regular teacher. d) Students in self-contained classes receive science instruction from their regular classroom teacher only. e) Students in self-contained classes pulled out for remedial instruction in science. f) Students in self-contained classes pulled out for enrichment in science. g) Students in self-contained classes pulled out from science instruction for additional instruction in other content areas.
Which best describes how science is most often taught in your school? • Science is taught all of most days, every week of the year. • Science is taught every week, but typically three or fewer days each week. • Science is taught some weeks, but not every week.	Which best describes how science is most often taught in your school? • Science is taught all of most days, every week of the year. • Science is taught every week, but typically three or fewer days each week. • Science is taught some weeks, but not every week.
In the last five years, has your school or district participated in any STEM initiatives at the elementary level?	In the last five years, has your school or district participated in any STEM initiatives at the elementary level?
Please describe the STEM initiative that your school or district participated in.	Please describe the STEM initiative that your school or district participated in.
What is the average length of a science class period, in minutes, for each grade level in science a) Third grade b) Fourth grade c) Fifth grade	In a typical year, how much instruction time is spent on science? • Average Number of Minutes per Day
Does your school provide the following to enhance students' interest and or achievement in science and/or engineering? a) Holds a family science and/or engineering night. b) Offers after-school help in science and/or engineering (for example: tutoring) c) Offers one or more science clubs d) Offers one or more engineering clubs e) Participates in local or regional science and/or engineering fair f) Has one or more teams participating in science competitions (for example: Science Olympiad) g) Has one or more teams participating in engineering competitions (for example: Robotics) h) Encourages students to participate in science and/or engineering summer	Does your school provide the following to enhance students' interest and or achievement in science and/or engineering? k) Holds a family science and/or engineering night. l) Offers after-school help in science and/or engineering (for example: tutoring) m) Offers one or more science clubs n) Offers one or more engineering clubs o) Participates in local or regional science and/or engineering fair p) Has one or more teams participating in science competitions (for example: Science Olympiad) q) Has one or more teams participating in engineering competitions (for example: Robotics) r) Encourages students to participate in science and/or engineering summer

programs or camps offered by community colleges, universities, museums, or science centers i) Sponsors visits to business, industry, and/or research sites related to science and/or engineering j) Sponsors meetings with adult mentors who work in science and/or engineering fields	programs or camps offered by community colleges, universities, museums, or science centers s) Sponsors visits to business, industry, and/or research sites related to science and/or engineering t) Sponsors meetings with adult mentors who work in science and/or engineering fields
Please indicate if in-service workshops offered by your school and/or district in the last three years addresses deepening teacher understanding of each of the following. • Science content • How students think about various science ideas • How to use particular science instructional materials (example: books or modules) • How to monitor student understanding during science instruction • How to adapt science instruction to address student misconceptions • How to use technology in science instruction • How to use investigation-oriented science teaching strategies • How to teach science to students who are English language learners • How to provide alternative science learning experiences for students with special needs • How to integrate science with other content areas	Consider all the opportunities to learn about science or the teaching of science in the last three years, how much importance was placed on each of the following? • Deepening your own science content knowledge. • Learning about difficulties that students may have with particular science ideas and procedures. • Finding out what students think or already know about the key science ideas prior to instruction on those ideas. • Implementing the science textbook/ module to be used in your classroom. • Planning instruction so students at different levels of achievement can increase their understanding of the ideas taught in each activity. • Monitoring student understanding during science instruction. • Providing enrichment experiences for gifted students. • Providing alternative science learning experiences for students with special needs. • Teaching science to English-language learners. • Assessing student understanding at the conclusion of instruction on a topic.
Please rate each of the following in terms of its importance for effective science instruction. • Provide concrete experience before abstract concepts • Develop students' conceptual understanding of the subject • Take students' prior understanding of a subject matter into account when planning curriculum and instruction • Make connections to other disciplines • Have students work in cooperative learning groups • Have students participate in appropriate hands-on activities • Have students work in mixed ability groups • Engage students in inquiry-oriented activities • Engage students in applications of subject matter in a variety of contexts • Encouraging students to provide evidence for their answers • Use of teacher questioning strategies to elicit student thinking and understanding	Think about your science instruction; identify how often you used each of the following practices in your science instruction? • Take students' prior understanding of a subject matter into account when planning curriculum and instruction. • Engage the whole class in discussions. • Have students work in small groups. • Do hands-on/ laboratory activities. • Engage the class in project-based learning (PBL) activities. • Make connections to other disciplines. • Have students read from a science textbook, module, or other science-related material in class, either aloud or to themselves. • Have students represent and/ or analyze data using tables, charts, or graphs. • Require students to supply evidence in support of their claims. • Have students make formal presentations to the rest of the class. • Have students write their reflections in class or for homework. • Give tests and/or quizzes that are predominately short-answer. • Give tests and/or quizzes that include constructed-response/ open ended items. • Focus on reading literacy skills. • Have students practice for standardized tests. Have students attend presentation by guest speakers focused on science and/or engineering in the workplace.

In your school does observation and feedback of science instruction occur?	During this school year have you been observed and received feedback on science instruction? • Observed during formal observation. • Observed during an informal or walk-through observation. •
When observing science instruction do you provide specific feedback on how to improve instruction?	During this school year have you been observed and received feedback on science instruction? • Received specific feedback on your science instruction.
When observing science do you look for reform-minded science practices? (for example: inquire, the learning cycle, 3E, 5E)	During this school year have you been observed and received feedback on science instruction? • Received specific feedback on reform-minded science practices. •
Do any of the following individuals provide science-focused one-on-one coaching in your school? a) The principal of your school b) An assistant principal at your school c) District administrators including science supervisors/coordinators d) Teachers/coaches who do not have classroom teaching responsibilities e) Teachers/coaches who have part-time classroom teaching responsibilities f) Teachers/coaches who have full-time classroom teaching responsibilities	Do any of the following individuals provide science-focused one-on-one coaching in your school? • The principal of your school. • An assistant principal at your school. • District administrators including science supervisors/ coordinators. • Teacher/ coaches who do not have classroom teaching responsibilities. • Researchers/ coaches who have part-time classroom teaching responsibilities. • Teachers/ coaches who have full-time classroom teaching responsibilities.
As an instructional leader do you monitor student progress in science?	My school principal makes an effort to monitor student progress in science?
This is your opportunity to tell me about your school. Why do you believe that your elementary school has been so successful at consistently attaining high-achievement in elementary science education?	This is your opportunity to tell me about your school. Why do you believe that your elementary school has been so successful at consistently attaining high-achievement in elementary science education?

Table A7. Characteristics by Percent of Participant Idaho Principals Leading Schools Achieving Highly in Science

	Total Principals		**Sample Principals**	
	Sample (N=23)	**Idaho (N=305)**	**Low-SES (n= 16)**	**High-SES (n= 7)**
Gender				
Male	48%	49%	47%	50%
Female	52%	51%	53%	50%
Race				
Caucasian	100%	98%	100%	100%
Hispanic	0%	2%	0%	0%
Age				
≤30	0%	1%	0%	0%
31-40	30%	25%	33%	25%
41-50	22%	20%	27%	12.5%
51-60	35%	37%	13%	62.5%
60+	13%	9%	27%	0%
Experience as a K-12 Principal				
0 years	4%	0%	7%	12.5%
2-5 years	17%	1%	20%	0%
6-10 years	39%	12%	47%	25%
11-20 years	35%	38%	20%	62.5%
≥ 21 years	4%	49%	7%	0%
Experience as a K-12 Principal at Current School				
1-2 years	39%	-	33%	50%
3-5 years	26%	-	33%	12.5%
6-10 years	30%	-	27%	37.5%
≥ 10 years	4%	-	7%	0%
Experience Teaching at the 6-12 Level				
1-2 years	4%	-	7%	0%
3-5 years	9%	-	13%	0%
6-10 years	39%	-	27%	62.5%
11-20 years	30%	-	47%	0%
≥ 21 years	17%	-	7%	37.5%
Experience Teaching Science at the 6-12 Level				
1 – 21+ years	22%	-	27%	12.5%

Table A8. Characteristics by Percent of Participant Idaho Teachers in Schools Achieving Highly in Science

	Total Teachers		Sample Teachers	
	Sample	Idaho	Low-SES	High-SES
Gender				
	(N=51)	(N = 8,808)	(n=14)	(n=37)
Male	18%	13%	16%	21%
Female	82%	87%	84%	79%
Race				
	(N=51)	(N=8,808)	(n=14)	(n=37)
Caucasian	100%	98%	100%	100%
American Indian or Native Alaskan	0%	5%	0%	0%
Hispanic	0%	1%	0%	0%
African American	0%	0.1%	0%	0%
Age				
	(N= 48)	(N=7948)	(n=14)	(n=34)
≤30	8%	17%	9%	7%
31-40	33%	23%	35%	29%
41-50	25%	25%	23.5%	29%
51-60	23%	30%	23.5%	21%
60+	10%	5%	9%	14%
Experience Teaching at the K-12 Level				
	(N=44)	(N=7948)	(n=12)	(n=32)
0 years	0%	11%	6%	17%
2-5 years	32%	18%	22%	25%
6-10 years	11%	18%	13%	8%
11-20 years	32%	29%	31%	33%
≥ 21 years	25%	24%	28%	17%
Experience Teaching Science at the K-12 Level				
	(N=44)		(n=12)	(n=32)
0 years	16%	-	15.5%	17%
2-5 years	23%	-	25%	17%
6-10 years	23%	-	15.5%	42%
11-20 years	18%	-	19%	17%
≥ 21 years	20%	-	25%	8%
Experience Teaching at the K-12 Level, in this school				
	(N=44)		(n=12)	(n=32)
0-2 years	23%	-	13%	50%
3-5 years	27%	-	28%	25%
6-10 years	25%	-	28%	17%
11-20 years	18%	-	25%	0%
≥ 21 years	7%	-	6%	8%
Experience Teaching at the K-12 Level, in this District				
	(N=47)		(n=13)	(n=34)
0-2 years	11%	-	6%	23%
3-5 years	23%	-	26%	15.5%
6-10 years	21%	-	21%	23%
11-20 years	28%	-	29%	23%
≥ 21 years	17%	-	18%	15.5%

Table A9. Percentage of Teachers who have taken Science and Engineering Coursework beyond Introductory Level, and Number of Courses Taken

	Teachers		
	Total (N=47)	Low-SES (n=35)	High-SES (n=12)
Chemistry	**2%**	**0%**	**8%**
Number of Classes Taken:	3	0	3
Organic chemistry	1	0	1
Inorganic chemistry	1	0	1
Biochemistry	1	0	1
Analytical chemistry	0	0	0
Physical chemistry	0	0	0
Life Science	**34%**	**29%**	**50%**
Number of Classes Taken:			
Anatomy/Physiology	6	4	2
Genetics	3	2	1
Ecology	6	4	2
Cell biology	4	3	1
Microbiology	4	3	1
Botany	3	2	1
Zoology	7	5	2
Evolution	2	0	2
Other	2	2	0
Physics	**11%**	**6%**	**25%**
Number of Classes Taken:			
Mechanics	2	1	1
Electrical and magnetism	1	1	0
Heat and thermodynamics	1	1	0
Modern or quantum physics	0	0	0
Optics	1	1	0
Nuclear physics	0	0	0
Other	2	1	1
Earth/Space Science	**4%**	**3%**	**8%**
Number of Classes Taken:			
Geology	0	0	0
Astronomy	2	1	1
Physical geography	1	1	0
Meteorology	0	0	0
Oceanography	0	0	0
Environmental Science	**6%**	**6%**	**8%**
Number of Classes Taken:			
Ecology	1	0	1
Conservation biology	1	1	0
Hydrology	0	0	0
Forestry	0	0	0
Other	1	1	0
Engineering	**2%**	**3%**	**0%**
Number of Classes Taken:			
Mechanical engineering	1	1	0
Chemical engineering	0	0	0
Computer engineering	0	0	0
Civil engineering	0	0	0
Biomedical engineering	0	0	0
Industrial/Manufacturing	0	0	0
engineering	0	0	0
Aerospace engineering	0	0	0

Table A10. Teacher Reported Median Time Spent on Instruction

	Teachers			Mann-Whitney U test, p-value
	Total (N=44)	Low-SES (n=32)	High-SES (n=12)	
Weeks Per Year				
Mathematics	36 (35, 36)	36 (35, 36)	36 (35, 37)	*U* = 140, *z* = -0.18, *p* = 0.89
Science	32 (20, 36)	32 (20, 36)	31 (26, 33)	*U* = 187, *z* = 0.196, *p* = 0.86
Social Studies	30 (18, 36))	30 (18, 36)	31 (25, 35)	*U* = 141, *z* = -0.15, *p* = 0.89
Reading/ Language Arts	36 (35, 36)	36 (35, 36)	36 (35, 37)	*U* = 147, *z* = -0.12, *p* = 0.91
Days Per Week				
Mathematics	36 (35, 36)	36 (35, 36)	36 (35, 37)	*U* = 131, *z* = -0.91, *p* = 0.89
Science	32 (20, 36)	32 (20, 36)	31 (26, 33)	*U* = 239, *z* = 1.82, *p* = 0.08
Social Studies	30 (18, 36))	30 (18, 36)	31 (25, 35)	*U* = 92, *z* = -1.79, *p* = 0.89
Reading/ Language Arts	36 (35, 36)	36 (35, 36)	36 (35, 37)	*U* = 135, *z* = -0.93, *p* = 0.91
Minutes Spent Per Day Taught				
Mathematics	70 (60, 80)	70 (60, 80)	68 (60, 83)	*U* = 144, *z* = -0.48, *p* = 0.65
Science	45 (40, 60)	45 (32.5, 60)	48 (45, 60)	*U* = 147, *z* = -1.23, *p* = 0.23
Social Studies	43 (30, 60)	40 (30, 50)	45 (30, 60)	*U* = 130, *z* = -0.92, *p* = 0.39
Reading/ Language Arts	90 (88, 120)	90 (79, 120)	36 (35, 37)	*U* = 180, *z* = 0.62, *p* = 0.57

Table A11. Teachers’ Median Ratings* of Frequency that they Engage Students in Various Teaching Practices

	Median Ratings by Teachers (IQR)			Mann-Whitney U test, p-value
	All (N=44)	Low-SES (n=31)	High-SES (n=12)	
Placing students in similar abilities groups.	1 (1, 3)	1 (1, 3)	1 (1, 3)	$U = 223$, $z = 0.88$, $p = 0.43$
Focusing on ideas in-depth, even if that means covering fewer topics.	4 (3, 5)	4 (3, 5)	4.5 (3, 5)	$U = 157$, $z = -0.98$, $p = 0.35$
Providing students with the purpose for a lesson as it begins.	5 (4, 5)	5 (4, 5)	4 (4, 5)	$U = 233$, $z = 1.23$, $p = 0.29$
Providing students with definitions for new scientific vocabulary that will be used at the beginning of instruction.	4 (4, 5)	4 (4, 5)	5 (3, 5)	$U = 168$, $z = -0.71$, $p = 0.52$
Explaining an idea to students before having them consider evidence that relates to the idea.	3 (3, 4)	4 (3, 4)	3 (3, 4)	$U = 235$, $z = 1.20$, $p = 0.27$
Reviewing previously covered ideas and skills during each class period.	4 (3, 5)	4 (3, 5)	4 (3, 4)	$U = 222$, $z = 0.83$, $p = 0.44$
Providing opportunities for students to share their thinking and reasoning each class period	5 (4, 5)	4 (4, 5)	5 (5, 5)	$U = 122$, $z = -2.03$, $p = 0.07$
Providing hands-on/laboratory activities primarily to reinforce a science idea that the students have already learned.	4 (3, 4)	4 (3, 4)	4 (3, 5)	$U = 123$, $z = -1.95$, $p = 0.07$
Assigning students homework most days.	4 (2, 3)	3 (2, 3)	3 (2, 3)	$U = 190$, $z = -0.06$, $p = 0.97$
Providing concrete experiences before abstract experiences.	4 (3, 4)	4 (3, 4)	4 (3, 4)	$U = 167$, $z = -0.57$, $p = 0.62$
Developing students’ conceptual understanding of a subject.	4 (4, 5)	4 (4, 5)	4 (4, 5)	$U = 175$, $z = -0.51$, $p = 0.65$
Engaging students in application of subject matter in a variety of contexts.	4 (4, 5)	4 (4, 4)	4.5 (3, 5)	$U = 154$, $z = -1.09$, $p = 0.32$

* (1) Never, (2) Rarely (A few times per year), (3) Sometimes (Once or twice per month), (4) Often (Once or twice per week), (5) All or almost all science classes.

Table A12. Teachers’ Median Ratings* of Frequency that they Engage Students in Various Teaching Practices, Based on Real-life Constraints

	Teachers			
	Total (N=43)	Low-SES (n=30)	High-SES (n=11)	Mann-Whitney U test, p-value
Taking students’ prior understanding of a subject matter into account when planning curriculum and instruction	4 (4, 5)	4 (3, 5)	4 (4, 5)	$U = 150, z = 1.18, p = 0.28$
Engaging the whole class in discussions	5 (4, 5)	5 (4, 5)	5 (4, 5)	$U = 204, z = 0.36, p = 0.77$
Having students work in small groups	4 (4, 5)	4 (4, 5)	4 (4, 5)	$U = 171, z = -0.61, p = 0.60$
Doing hands-on/ laboratory activities	4 (3, 4)	3 (3, 4)	4 (4, 5)	$U = 105, z = -2.32, p = 0.03$
Engaging the class in project-based learning (PBL) activities	3 (2, 4)	3 (2, 4)	4 (3, 4)	$U = 128, z = -1.75, p = 0.10$
Making connections to other disciplines	4 (3, 4)	4 (3, 4)	4 (3, 5)	$U = 167, z = -0.75, p = 0.51$
Having students read from a science textbook or other related materials in class, either aloud or to themselves	4 (3, 4)	4 (3, 4)	4 (3, 4)	$U = 226, z = 0.93, p = 0.38$
Having students represent and/or analyze using tables, charts, or graphs	3 (3, 4)	3 (3, 4)	4 (3, 4)	$U = 180, z = -0.34, p = 0.76$
Requiring students to supply evidence in support of their claims	4 (2, 4)	4 (3, 5)	4 (3, 4)	$U = 163, z = -0.81, p = 0.46$
Having students make formal presentations to the rest of the class	3 (2, 4)	3 (2, 4)	3 (2, 4)	$U = 167, z = -0.54, p = 0.62$
Having students write their reflections in class or for homework	3 (3, 4)	3 (3, 4)	4 (3, 5)	$U = 97, z = -2.31, p = 0.03$
Giving tests and/or quizzes that are predominantly short-answer	3 (2, 3)	3 (2, 3)	3 (2, 4)	$U = 197, z = 0.13, p = 0.91$
Giving tests and/or quizzes that include constructed-response/ open-ended items	3 (3, 4)	3 (3, 4)	3 (3, 3)	$U = 203, z = 0.32, p = 0.79$
Focusing on literacy skills (for example: informational reading or writing skills)	4 (3, 4)	4 (2, 4)	4 (3, 4)	$U = 183, z =-0.25, p = 0.83$
Having students practice for standardized tests	2 (2, 3)	2 (2,3)	2 (1, 3)	$U = 249, z = 1.57, p = 0.14$
Having students attend presentations by guest speakers focused on science and/or engineering in the workplace	2 (1, 2)	2 (1, 2)	2 (2, 3)	$U = 126, z =-1.87, p = 0.08$

* (1) Never, (2) Rarely (A few times per year), (3) Sometimes (Once or twice per month), (4) Often (Once or twice per week), (5) All or almost all science classes.

Table A13. Principals’ Median Ratings* of Importance for Various Instructional Practices

	Principals			
	Total (N=43)	Low-SES (n=30)	High-SES (n=11)	Mann-Whitney U test, p-value
Provide concrete experience before abstract concepts	5 (4, 5)	5 (4, 5)	5 (4, 5)	$U = 58$, $z = -0.15$, $p = 0.93$
Develop students’ conceptual understanding of the subject	5 (4, 5)	5 (4, 5)	4.5 (4, 5)	$U = 64$, $z = 0.25$, $p = 0.83$
Take students’ prior understanding of a subject matter into account when planning curriculum and instruction	4 (4, 5)	4 (4, 5)	4 (4, 5)	$U = 63$, $z = 0.22$, $p = 0.88$
Make connections to other disciplines	5 (4, 5)	5 (4, 5)	5 (4, 5)	$U = 60$, $z < 0.01$, $p = 1.00$
Have students work in cooperative learning groups	4 (3, 5)	4 (3, 5)	4 (2, 5)	$U = 75$, $z = 0.98$, $p = 0.36$
Have students participate in appropriate hands-on activities	5 (5, 5)	5 (4, 5)	5 (5, 5)	$U = 47$, $z =-0.89$, $p = 0.53$
Have students work in mixed ability groups	4 (3, 5)	4 (3, 5)	4 (2, 5)	$U = 69$, $z = 0.60$, $p = 0.59$
Engage students in inquiry-oriented activities	4 (4, 5)	5 (4, 5)	4 (3, 5)	$U = 72$, $z = 0.81$, $p = 0.47$
Engage students in application of subject matter in a variety of contexts	4 (4, 5)	5 (4, 5)	4 (4, 5)	$U = 68$, $z = 0.57$, $p = 0.64$
Encouraging students to provide evidence for their answers	5 (4, 5)	5 (4, 5)	5 (4, 5)	$U = 54$, $z = -0.48$, $p = 0.73$
Use of Teacher questioning strategies to elicit student thinking and understanding	5 (4, 5)	5 (4, 5)	5 (4, 5)	$U = 54$, $z = -0.48$, $p = 0.73$

*(1) Unimportant, (2) Of little importance, (3) Moderately important, (4) Important, (5) Very Important.

Table A14. Principal and Teacher Agreement on the High-quality Science Teaching Practices and Access to Science Equipment and Facilities, as Primary Indicators of Program and Practice

School	Use of reform-oriented teaching practices and instructional objectives	Doing hands-on or laboratory activities	Having students represent or analyze data using tables, charts, or graphs	Requiring students to supply evidence in support of their claims	Visiting STEM sites or having guest speakers from STEM fields	Access to Science Equipment and Consumable Items	Access to Science Facilities
Helium Elementary	Present						
Beryllium Elementary	Present	Present	Present	Present	Present		Present
Boron Elementary	Present		Present	Present		Present	Present
Carbon Elementary	Present	Present	Present	Present			
Oxygen Elementary	Present	Present	Present	Present		Present	
Nitrogen Elementary	Present				Present		Present
Fluorine Elementary	Present	Present	Present	Present			Present
Neon Elementary	Present	Present	Present	Present		Present	Present
Sodium Elementary	Present	Present	Present	Present	Present		Present
Magnesium Elementary	Present	Present	Present	Present	Present	Present	
Aluminum Elementary	Present	Present	Present		Present		

Silicon Elementary		Present	Present	Present	Present		
Phosphorus Elementary	Present		Present	Present	Present		
Sulfur Elementary	Present						Present
Chlorine Elementary	Present		Present	Present			Present
Argon Elementary					Present		
Potassium Elementary	Present			Present	Present		
Calcium Elementary	Present						

APPENDIX B

Recruitment Materials

Phone Protocol

“Hello, my name is Jill Hettinger. I am a researcher at Boise State University. I am conducting a research study to identify factors influencing high science achievement in elementary schools within the state of Idaho. More specifically, this study is also interested in how these factors differ between low-SES and high-SES schools. You are being asked to complete this survey because your school has been identified as a high achieving elementary school in science, and your school fits within the low or high-SES demographic. I am calling you because I have identified your school as a school that has had consistent high achievement on the elementary science ISAT.

If you would be interested in participating in the study, I will be sending you a link to the internet-based survey. If you are interested in participating in the study I encourage you to complete the survey.

If you have questions, I can be reached at 208-871-7414 or jillhettinger@boisestate.edu. Thank you for your help in helping us to learn more about elementary science education.

If not interested, investigator will end the call: “Thank you for your time.”

Superintendent Letter – Study Invite
[Date]

(Boise State Logo)

[Superintendents name], [professional title]

[District name]

Dear [Mr./Mrs./Dr.] [Superintendent last name]:

I am a doctoral student at Boise State University in Education, Curriculum and Instruction – STEM leadership involved in a research study evaluating effects of school-wide factors in high-achieving elementary science education programs. More specifically, I will be looking at what school-wide factors help low-SES schools achieve in elementary science education, as compared to school-wide factors identified in high-SES schools. For this reason, I am interested in high-achieving low-SES and high-SES schools.

I would like to invite [school(s) name] to participate in a principal survey because of [school(s) name] consistent high achievement on the fifth grade science ISAT.

[schools name] in [district] will be a part of a statewide sample of about 40 schools. I would like to begin contacting school principals in the coming weeks with their survey.

I want to assure you that no data will be collected from students, and there will be no intrusion on the instructional day. All information in the survey will be kept anonymous and confidential, including: the participating principal's name, school name, and district name. In any articles written or presentation made, names or descriptive identifiers will not be given.

The survey consists of a few background questions, followed by questions on the following five categories: programs and practices, science budget, influences on science instruction, science professional development opportunities, and instructional leadership.

I am excited to begin this important statewide study and look forward to working with the sampled schools in [District name]. [District name]'s participation is voluntary, but very important and greatly appreciated If you have any questions about the study you can contact me at (208) 871-7414 or email (jillhettinger@boisestate.edu).

Warm regards,

Jill K. Hettinger
Doctoral Candidate
Education, Curriculum and Instruction – STEM leadership
Boise State University

Principal E-mail – Study Invite
(Boise State Logo)

Dear [Mr./Ms./Dr.] [Principal last name]: (or current Principal)

I am a doctoral student at Boise State University in Education, Curriculum and Instruction – STEM leadership. I am involved in a research study evaluating school-wide factors in high-achievement in elementary science education. More specifically, I will be looking at what school-wide factors help low-SES schools achieve in elementary science education, as compared to school-wide factors identified in high-SES schools. For this reason I am interested in high-achieving low-SES and high-SES schools.

As the principal of [school name] I would like to invite you to participate in a principal survey because of [school(s) name] consistent high achievement on the fifth grade science ISAT. The survey consists of a few background questions, followed by questions on the following five categories: programs and practices, science budget, influences on science instruction, science professional development opportunities, and instructional leadership.

I have designed the study to strictly avoid intrusions on the instructional day and to place a minimal burden on principals and teachers. In addition, no data will be collected from students. All information in the survey will be kept anonymous and confidential; your name will not appear anywhere and no one will know about your specific answers except me and my dissertation committee chair, Dr. Ted Singletary. I will assign a number to your responses and I will have the key to indicate which number belongs to which participant. In any article written or presentation made, names or descriptive identifiers will not be given. The name of your school and district will also remain anonymous and confidential.

This study specifically will be looking at what school-wide factors help low-SES schools achieve in elementary science education. This study will also look at how these factors compare to factors identified in high-SES schools. For this reason I am interested in high-achieving low-SES and high-SES schools.

Your participation is voluntary, but very important and greatly appreciated. If you have any questions about the study, please contact me at (208) 871-7414 or email (jillhettinger@boisestate.edu).

Warmest regards,

Jill K. Hettinger
Doctoral Candidate
Education, Curriculum and Instruction – STEM leadership
Boise State University

Teacher E-mail – Study Invite
(Boise State Logo)

Dear (Teacher Participant's Name),

My name is Jill Hettinger and I am a doctoral candidate at Boise State University in Education, Curriculum and Instruction – STEM leadership. I am conducting a research study titled: **Finding Success in Elementary Science across Socioeconomic Boundaries** .The purpose of this study is to identify factors influencing high science achievement in elementary schools, within the state of Idaho. I am also interested in how these factors differ between low-SES and high-SES schools.

As a teacher at [school name] I would like to invite you to participate in the teacher survey because [school's name] consistent high achievement on the fifth grade science ISAT. The survey targets the following four areas: programs and practice, professional development, instructional leadership, and assessment.

The survey is administered through the internet, to provide minimal burden to you. In addition, no data will be collected from students. All of the information in the survey will be kept confidential. In any article written or presentations made, names and descriptive identifiers will not be given.

Your participation is voluntary, but very important and greatly appreciated. This study involves no foreseeable serious risks. We ask that you try to answer all questions; however, if there are any items that make you uncomfortable or that you would prefer to skip, please leave the answer blank. Your responses will be kept confidential.

If you are interested, please click on the link for the survey and additional information: www.linktosurvey.com.

Please note that in seven days a friendly reminder will be sent out if you have not responded.

If you have any questions or concerns feel free to contact me or my faculty advisor:

Jill Hettinger, Doctoral Candidate
Curriculum & Instruction
Boise State University
(208) 871-7414
jillhettinger@boisestate.edu

Dr. Ted Singletary, Professor
Curriculum, Instruction, & Foundational Studies
Boise State University
(208) 426-3270
tedsingle@boisestate.edu

Thank you for your assistance,
Jill Hettinger
Doctoral Candidate Education – Curriculum & Instruction, Boise State University

APPENDIX C

Tools

Principal Survey Tool

Q1.1 Finding Success in Elementary Science across Socioeconomic Boundaries - Principal Survey

Q1.2 Informed Consent

Study Title: Finding Success in Elementary Science across Socioeconomic Boundaries

Principal Investigator: Jill Hettinger, Doctoral Candidate, Boise State University

Co-Investigator: Dr. Ted Singletary, Boise State University Approved

IRB Protocol Number: 170-SB13-103

Purpose: The purpose of this research study is to identify factors influencing high science achievement in elementary schools within the state of Idaho. More specifically, this study is also interested in how these factors differ between low and high socioeconomic schools. You are being asked to participate in this study because your school has consistently shown high achievement in elementary science on the science ISAT.

Procedures: If you agree, you will participate in the study through the completion on an Internet-based survey that will ask questions about the following four areas: Programs and Practice Instructional Leadership Teacher Background and Professional Development Assessment and Feedback. The survey will take approximately 15-20 minutes.

Risks: The survey will include a section requesting demographic information. Due to the make-up of Idaho's population, the combined answers to these questions may make an individual person identifiable. We will make every effort to protect participants' confidentiality. However, if you are uncomfortable answering any of these questions, you may leave them blank. In the unlikely event that some of the survey or interview questions make you uncomfortable or upset, you are always free to decline to answer or to stop your participation at any time.

Benefits: There will be no direct benefit to you from participating in this study. However, the information that you provide may help develop improved study habits for college students.

Extent of Confidentiality: Reasonable efforts will be made to keep the personal information in your research record private and confidential. Any identifiable information obtained in connection with this study will remain confidential and will be disclosed only with your permission or as required by law. The members of the research team, and the Boise State University Office of Research Compliance (ORC) may access the data. The ORC monitors research studies to protect the rights and welfare of research participants. Your name will not be used in any written reports or publications which result from this research. Data will be kept for three years (per federal regulations) after the study is complete and then destroyed.

Payment: You will not be paid for your participation in this study.

Participation is Voluntary: You do not have to be in this study if you do not want to. You may also refuse to answer any questions you do not want to answer. If you volunteer to be in this study, you may withdraw from it at any time without consequences of any kind or loss of benefits to which you are otherwise entitled.

Questions: If you have any questions or concerns about your participation in this study, you may contact the principal investigator, Jill Hettinger or her faculty advisor:

Jill Hettinger, Doctoral Candidate	Dr. Ted Singletary, Professor
Curriculum & Instruction	Curriculum & Instruction
Boise State University	Boise State University
(208) 871-7414	(208) 426-4006
jillhettinger@boisestate.edu	tsingle@boisestate.edu

If you have questions about your rights as a research participant, you may contact the Boise State University Institutional Review Board (IRB), which is concerned with the protection of volunteers in research projects. You may reach the board office between 8:00 AM and 5:00 PM, Monday through Friday, by calling (208) 426-5401 or by writing: Institutional Review Board, Office of Research Compliance, Boise State University, 1910 University Dr., Boise, ID 83725-1138.

Documentation of Consent:

○ I have read this form and decided that I will participate in the project described above. Its general purpose, the particulars of involvement and possible risks have been explained to my satisfaction. I understand I can withdraw at any time.
○ I have read this form and decided to NOT participate in the project as described above.

If *I have read this form and decided to NOT participate in the project as described above.* Is Selected, Then Skip To End of Survey

Q2.1 What is your ethnic origin?

○ American Indian/ Alaskan Native
○ Hispanic
○ Asian/ Pacific Islander
○ Caucasian
○ African American

Q2.2 What is your gender?

○ Male
○ Female

Q2.3 What is your age?

Age

Q2.4 At the end of the last school year, how many years...

...had you been a principal?
...had you been the principal of this school?
...teaching experience did you have?

Q2.5 At what grade levels have you taught? If at the secondary level, what subjects?

☐ K-5
☐ 6-8 ____________________
☐ 9-10 ____________________

Q3.1 Indicate whether each of the following programs and/or practices are currently being implemented in your school:

	Yes	No
a) Students receive science instruction from a science specialist instead of their regular teacher.	○	○
b) Students in self-contained classes receive science instruction from a science specialist in addition to their regular teacher.	○	○
c) Students in self-contained classes are pulled out for remedial instruction in science.	○	○
d) Students in self-contained classes are pulled out for enrichment in science.	○	○
e) Students in self-contained classes are pulled out of science instruction for additional instruction in other content areas.	○	○
f) Students in self-contained classes receive science instruction from their regular classroom teacher only.	○	○

Q38 How is science taught in your school?

	K	1	2	3	4	5
Science is taught all or most days, every week of the year.	☐	☐	☐	☐	☐	☐
Science is taught every week, but typically three or fewer days each week.	☐	☐	☐	☐	☐	☐
Science is taught some weeks, but typically not every week.	☐	☐	☐	☐	☐	☐

Q3.3 What is the average length of a science class period, in minutes, for each grade level in science?

	Minutes per Science Class Period
Kindergarten	
First Grade	
Second Grade	
Third Grade	
Fourth Grade	
Fifth Grade	

Q3.4 Does your school provide the following to enhance students' interests and or achievement in science and/or engineering?

	Yes	No
a) Holds a family science and/or engineering night.	○	○
b) Offers after-school help in science and/or engineering (for example: tutoring)	○	○
c) Offers one or more science/engineering clubs	○	○
e) Participates in local or regional science and/or engineering fair	○	○
f) Has one or more teams participating in science/engineering competitions (for example: Science Olympiad, Robotics, Future City)	○	○
g) Encourages students to participate in science and/or engineering summer programs or camps offered by community colleges, universities, museums, or science centers	○	○
h) Sponsors visits to business, industry, and/or research sites related to science and/or engineering	○	○
i) Sponsors meetings with adult mentors who work in science and/or engineering	○	○

fields		

Q3.5 Please provide your opinion about each of the following statements in regard to state standards for science.

	Yes	No
a) I am knowledgeable about the Idaho Content Standards in science	○	○
b) There is a school-wide effort to align science instruction with the state science standards	○	○
c) Most science teachers in this school teach to the state science standards	○	○
d) Your district organizes science professional development based on state standards	○	○
e) I am knowledgeable about the Common Core State Standards	○	○
f) I am knowledgeable about the Next Generation Science Standards	○	○

Q3.6 For this school, how much money was spent on each of the following during the most recently completed budget year? (If you don’t know exact amounts, please provide your best estimate.) [Enter each response as a whole dollar amount (for example: 1500); do not include commas or dollar signs.]

______ a.) Consumable science supplies (For example: chemicals, living organisms, batteries)
______ b.) Science equipment (non-consumable, non-perishable items such as microscopes, scales, etc., but not computers)
______ c.) Software for science instruction

Q3.7 Are the following sources of funding used to support your schools science program?

	Yes	No
a) State/district funding	○	○
b) Title I funding	○	○
c) Title II funding	○	○
d) Parent donations	○	○
e) Community donations	○	○
f) Teacher donations	○	○
g) Grants received by teachers	○	○
h) Grants received by the school	○	○
i) Grants received by the District	○	○
j) Fundraiser and/or PTO funds	○	○

Q3.8 Please rate each of the following in terms of its importance for effective science instruction.

	Unimportant	Of Little Importance	Moderately Important	Important	Very Important
a) Provide concrete experience before abstract concepts	○	○	○	○	○
b) Develop students' conceptual understanding of the subject	○	○	○	○	○
c) Take students' prior understanding of a subject matter into account when planning curriculum and instruction	○	○	○	○	○
d) Make connections to other disciplines	○	○	○	○	○
e) Have students work in cooperative learning groups	○	○	○	○	○

f) Have students participate in appropriate hands-on activities	○	○	○	○	○
g.) Have students work in mixed ability groups	○	○	○	○	○
h) Engage students in inquiry-oriented activities	○	○	○	○	○
i) Engage students in applications of subject matter in a variety of contexts	○	○	○	○	○
j) Encouraging students to provide evidence for their answers	○	○	○	○	○
k) Use of teacher questioning strategies to elicit student thinking and understanding	○	○	○	○	○

Q3.9 In your opinion, how great a problem is each of the following for science instruction in your school as a whole?

	Unimportant	Of Little Importance	Moderately Important	Important	Very Important
a) Lack of science facilities (for example: lab tables, electrical outlets, facets and sinks in classroom)	○	○	○	○	○
b) Inadequate funds for purchasing science equipment and supplies	○	○	○	○	○
c) Inadequate supply of science textbooks/modules	○	○	○	○	○
d) Inadequate materials for individualizing science instruction	○	○	○	○	○
e) Low student interest in science	○	○	○	○	○
f) Low student reading abilities	○	○	○	○	○
g) Interruptions for announcements, assemblies, and other school activities	○	○	○	○	○

h) Large class sizes	○	○	○	○	○
i) High student absenteeism	○	○	○	○	○
j) Inappropriate student behavior	○	○	○	○	○
k) Lack of parental support for science education	○	○	○	○	○
l) Community attitudes towards science instruction	○	○	○	○	○
m) Conflict between efforts to improve science instruction and other school and/or district initiatives	○	○	○	○	○
n) How science instructional resources are managed (for example distribution and refurbishment of materials)	○	○	○	○	○

Q4.1 In the last five years has your school or district participated in any STEM initiatives?

○ Yes
○ No

Answer If *In the last five years has your school or district participated in any STEM initiatives?* Yes Is Selected

Q4.2 Please describe the STEM initiatives that your school or district has participated in. What years? Who sponsored the initiative? Did the initiative have a name or can you describe the initiative?

Q4.6 In your opinion, how great a problem is each of the following for science instruction in your school as a whole?

	Unimportant	Of Little Importance	Moderately Important	Important	Very Important
a) Lack of teacher interest in science	○	○	○	○	○
b) Inadequate teacher preparation to teach science	○	○	○	○	○
c) Lack of teachers' science knowledge	○	○	○	○	○
d) Insufficient time to teach science	○	○	○	○	○
e) Lack of opportunities for science teachers to share ideas	○	○	○	○	○
f) Inadequate science-related professional development opportunities	○	○	○	○	○

Q4.3 In the last three years, has your school and/or district offered in-service workshops specifically focused on science or science teaching?

- ○ Yes
- ○ No

If No Is Selected, Then Skip To *In the last three years, has your school offered teacher study groups where teachers meet on a regular basis to discuss teaching and learning of science (sometimes referred to as Professional Learning Communities, PLCs, or lesson study)?*

Q4.4 Please indicate if in-service workshops offered by your school and/or district in the last three years addresses deepening teacher understanding of each of the following:

	Yes	No
a) Science content	○	○
b) State science standards	○	○
c) Common Core State Standards	○	○
d) How to use particular science instructional materials (example: books or modules)	○	○
e) How students think about various science ideas	○	○
f) How to monitor student understanding during science instruction	○	○
g) How to adapt science instruction to address student misconceptions	○	○
h) How to use technology in science instruction	○	○
i) How to use investigation-oriented science teaching strategies	○	○
j) How to teach science to students who are English language learners	○	○
k) How to provide alternative science learning experiences for students with	○	○

special needs		
l) How to integrate science with other content areas	○	○

Q4.7 In the last three years, has your school offered teacher study groups where teachers meet on a regular basis to discuss teaching and learning of science (sometimes referred to as Professional Learning Communities, PLCs, or lesson study)?

○ Yes
○ No

If No Is Selected, Then Skip To *Think about last school year, were the following used to provide teachers in this school with time for in-service workshops/teacher study groups that include a focus on science content and/or science instruction, regardless of whether they were offered by your school and/or district?*

Q4.8 Are teachers of grades K-5 science classes required to participate in these science-focused teacher study groups?

○ Yes
○ No

Q4.9 Do these statements describe the typical science-focused teacher study groups in this school?

	Yes	No
a) Teacher engage in science investigations	○	○
b) Teachers plan science lessons together	○	○
c) Teachers analyze student science assessment results	○	○
d) Teachers analyze classroom artifacts (for example: Student work samples)	○	○
e) Teachers analyze science instructional materials (for example: textbooks or modules)	○	○

Answer If In the last three years, has your school offered teacher study groups where teachers meet on a regular basis to discuss teaching and learning of science (sometimes referred to as Professional Learning Communities, PLCs, or lesson study)? Yes Is Selected Or In the last three years, has your school and/or district offered in-service workshops specifically focused on science or science teaching? Yes Is Selected

Q4.5 Think about last school year, were the following used to provide teachers in this school with time for in-service workshops/teacher study groups that include a focus on science content and/or science instruction, regardless of whether they were offered by your school and/or district?

	Yes	No
a) Early dismissal and/or late start for students	○	○
b) Professional days/teacher work days during the students' school year	○	○
c) Common planning time for teachers	○	○
d) Substitute teacher to cover teachers' classes while they attend professional development	○	○

Q5.1 In your school does observation and feedback of science instruction occur?

○ Yes
○ No

If No Is Selected, Then Skip Do any of the following individuals provide science-focused one-on-one coaching in your school?

Q5.2 How often during this school year have you observed in any one classroom during science instruction?

______ a) During a formal observation
______ b) During an informal or walk through observation

Q5.3 When observing science do you look for reform-minded science practices? (for example: inquire, the learning cycle, 3E, 5E)

- ○ Yes
- ○ No

Q5.4 When observing science instruction do you provide specific feedback on how to improve instruction?

- ○ Yes
- ○ No

Q5.5 Do any of the following individuals provide science-focused one-on-one coaching in your school?

	Yes	No
a) The principal of your school	○	○
b) An assistant principal at your school	○	○
c) District administrators including science supervisors/coordinators	○	○
d) Teachers/coaches who do not have classroom teaching responsibilities	○	○
e) Teachers/coaches who have part-time classroom teaching responsibilities	○	○
f) Teachers/coaches who have full-time classroom teaching responsibilities	○	○

Q5.6 Teachers that you considered in need of special assistance in science teaching are provided:

	Yes	No
a) Seminars, classes, and/or study groups	○	○
b) A higher level of supervision than for other teachers	○	○
c) Guidance from a formally designated mentor or coach	○	○

Q6.1 Teachers' in my school use the following assessment strategies in science?

	Yes	No
a) Diagnostic assessments to determine prior knowledge and misconceptions	○	○
b) Formative or embedded assessment to make informed decisions about their teaching, to adjust the rate of instruction, assign remediation activities, and plan alternative experiences	○	○
c) Summative assessments, such as end of unit exams	○	○
d) Performance assessment that allow students to demonstrate their abilities	○	○
e) Use of science notebooks	○	○
f) Use of portfolios	○	○
g) Student self-assessment	○	○
h) Assessments aligned to district or state standards	○	○

Q6.2 Teachers in my school make the following changes in whole class science instruction based on data:

	Yes	No
a) Change lesson plans to place more emphasis in areas in which the group	○	○
b) Add more projects and exercises in areas in which the class scored low	○	○
c) Request additional supplies or equipment	○	○
d) Re-evaluate textbooks and learning materials based on results of assessment	○	○
e) Discuss curriculum relevance and alignment with standards and assessment with peers	○	○
f) Ask for additional support and ideas from other teachers or administrators	○	○

Q6.3 Teachers in my school make the following changes in individual student science instruction based on data:

	Yes	No
a) Provide students with additional assistance during class in areas in which they performed poorly	○	○
b) Provide students with additional assistance outside of class in areas in which they performed poorly	○	○
c) Provide poorly performing students with materials on test-taking skills and strategies	○	○
d) Provide high-performing students with additional, more challenging projects and/or readings	○	○

Q6.4 As an instructional leader do you monitor student progress in science?

○ Yes
○ No

Q7.1 This is your opportunity to tell me about your school. Why do you believe that your elementary school has been so successful at consistently attaining high-achievement in elementary science education?

Teacher Survey Tool

Q1.1 Finding Success in Elementary Science across Socioeconomic Boundaries - Teacher Survey

Q1.2 Informed Consent
Study Title: Finding Success in Elementary Science across Socioeconomic Boundaries
Principal Investigator: Jill Hettinger, Doctoral Candidate, Boise State University
Co-Investigator: Dr. Ted Singletary, Boise State University
Approved IRB Protocol Number: 170-SB13-103

Purpose: The purpose of this research study is to identify factors influencing high science achievement in elementary schools within the state of Idaho. More specifically, this study is also interested in how these factors differ between low and high socioeconomic schools. You are being asked to participate in this study because your school has consistently shown high achievement in elementary science on the science ISAT.
Procedures: If you agree, you will participate in the study through the completion on an Internet-based survey that will ask questions about the following four areas: Programs and Practice, Instructional Leadership, Teacher Background, and Professional Development Assessment and Feedback. The survey will take approximately 20-30 minutes.

Risks: The survey will include a section requesting demographic information. Due to the make-up of Idaho’s population, the combined answers to these questions may make an individual person identifiable. We will make every effort to protect participants’ confidentiality. However, if you are uncomfortable answering any of these questions, you may leave them blank. In the unlikely event that some of the survey or interview questions make you uncomfortable or upset, you are always free to decline to answer or to stop your participation at any time.

Benefits: There will be no direct benefit to you from participating in this study. However, the information that you provide may help develop improved study habits for college students.
Extent of Confidentiality: Reasonable efforts will be made to keep the personal information in your research record private and confidential. Any identifiable information obtained in connection with this study will remain confidential and will be disclosed only with your permission or as required by law. The members of the research team, the and the Boise State University Office of Research Compliance (ORC) may access the data. The ORC monitors research studies to protect the rights and welfare of research participants. Your name will not be used in any written reports or publications which result from this research. Data will be kept for three years (per federal regulations) after the study is complete and then destroyed.

Payment: You will not be paid for your participation in this study.

Participation is Voluntary: You do not have to be in this study if you do not want to. You may also refuse to answer any questions you do not want to answer. If you volunteer to be in this study, you may withdraw from it at any time without consequences of any kind or loss of benefits to which you are otherwise entitled.

Questions: If you have any questions or concerns about your participation in this study, you may contact the principal investigator, Jill Hettinger or her faculty advisor:

Jill Hettinger, Doctoral Candidate	Dr. Ted Singletary, Professor
Curriculum & Instruction	Curriculum & Instruction
Boise State University	Boise State University
(208) 871-7414	(208) 426-3270
jillhettinger@boisestate.edu	tsingle@boisestate.edu

If you have questions about your rights as a research participant, you may contact the Boise State University Institutional Review Board (IRB), which is concerned with the protection of volunteers in research projects. You may reach the board office between 8:00 AM and 5:00 PM, Monday through Friday, by calling (208) 426-5401 or by writing: Institutional Review Board, Office of Research Compliance, Boise State University, 1910 University Dr., Boise, ID 83725-1138.

Documentation of Consent:

- ○ I have read this form and decided that I will participate in the project described above. Its general purpose, the particulars of involvement and possible risks have been explained to my satisfaction. I understand I can withdraw at any time.
- ○ I have read this form and decided to not participate in the project as described above.

Q2.1 Background

Q2.2 What is your gender?

- ○ Male
- ○ Female

Q2.3 What is your ethnic origin?

- ○ American Indian/ Alaskan Native
- ○ Hispanic
- ○ Asian/ Pacific Islander
- ○ Caucasian
- ○ African American

Q2.4 What is your age?

Age

Q2.5 Which of the following describes your position? [Select all that apply]

- ☐ Regular classroom teacher
- ☐ Multi-grade science specialist
- ☐ Science teacher for my grade level team

Q2.6 At the end of last school year, how my years had you taught. [response as a whole number].

	Years taught (1)
in this district, any subject? (5)	
in this school, any subject? (6)	
any subject at the K-12 level? (9)	
as a dedicated science teacher at the K-12 level? (7)	
science as a part of the grade-level curriculum at the K-12 level? (2)	

Q2.7 Which best describes how science is most often taught in your school?

○ Science is taught all or most days, every week of the year.
○ Science is taught every week, but typically three or fewer days each week.
○ Science is taught some weeks, but typically not every week.

Q2.8 At what grade levels do you currently teach science? [Select all that apply.]

☐ K-5
☐ 6-8
☐ 9-12
☐ You do not currently teach science

If *You do not currently teach science*. Is Selected, Then Skip To End of Survey

Answer If Which of the following describes your position? [Select all that apply]-Multi-grade science specialist Is Not Selected

Q2.9 In a typical year, how much instructional time do you spend in each subject? [Enter each response as a whole number (for example: 36, 150).]

	Number of Weeks per Year	Number of Days per Week	Average Number of Minutes per Day
Mathematics			
Science			
Social Studies			
Reading/Language Arts			

Answer If *Which of the following describe your position? [Select all that apply] Multi-grade science specialist* Is Selected

Q2.10 In a typical year, how much instructional time is spent in science at each grade level? [Enter each response as a whole number (for example: 36, 150).]

	Number of Weeks per Year	Number of Days per Week	Average Number of Minutes per Day
K			
1			
2			
3			
4			
5			

Q3.1 Science Background and Professional Development

Q3.2 Have you been awarded one or more bachelor’s and/or graduate degrees in the following fields? (With regard to bachelor’s degrees, count only areas in which you majored.) [Select one on each row.]

	Yes	No
a) Education, including science education	○	○
b) Natural Sciences and/or Engineering	○	○
c) Other, please specify	○	○

Answer If Have you been awarded one or more bachelor's and/or graduate degrees in the following fields? (With regard to bachelor's degrees, count only areas in which you majored.) a) Education, including science education - Yes Is Selected

Q3.3 What type of education degree do you have? (With regard to bachelor's degrees, count only areas in which you majored.) [Select all that apply.]

☐ Elementary Education
☐ Mathematics Education
☐ Science Education
☐ Secondary Education
☐ Other Education, please specify. ____________________

Answer If *Have you been awarded one or more bachelor's and/or graduate degrees in the following fields? (With regard to bachelor's degrees, count only areas in which you majored.) b) Natural Sciences and/or Engineering* - Yes Is Selected

Q3.4 What type of natural science and/or engineering degree do you have? (With regard to bachelor's degrees, count only areas in which you majored.) [Select all that apply.]

○ Biology/Life Science
○ Chemistry
○ Earth/Space Science
○ Engineering
○ Environmental Science/Ecology
○ Physics
○ Other natural science, please specify. ____________________

Q3.5 Did you complete any of the following types of biology/life science courses at the undergraduate or graduate level? [Select one on each row.]

	Yes	No
General/introductory biology/life science courses (for example: Biology I, Introductory to Biology)	○	○
Biology/life science courses beyond the general/introductory level	○	○
Biology/life science education courses	○	○

Answer If *Did you complete any of the following types of biology/life science courses at the undergraduate or graduate level? Biology/life science courses beyond the general/introductory level* - Yes Is Selected

Q3.6 Please indicate which of the following biology/life science courses you completed (beyond a general/introductory course) at the undergraduate or graduate level. [Select all that apply.]

- ☐ Anatomy/Physiology
- ☐ Biochemistry
- ☐ Botany
- ☐ Cell Biology
- ☐ Ecology
- ☐ Evolution
- ☐ Genetics
- ☐ Microbiology
- ☐ Zoology
- ☐ Other biology/life science beyond the general/introductory level

Q3.7 Did you complete any of the following types of chemistry courses at the undergraduate or graduate level? [Select one on each row.]

	Yes	No
General/introductory chemistry courses (for example: Chemistry I, Introduction to Chemistry)	○	○
Chemistry courses beyond the general/introductory level	○	○
Chemistry education courses	○	○

Answer If *Did you complete any of the following types of chemistry courses at the undergraduate or graduate level? Chemistry courses beyond the general/introductory level* - Yes Is Selected

Q3.8 Please indicate which of the following chemistry courses you completed (beyond a general/introductory course) at the undergraduate or graduate level. [Select all that apply.]

- ☐ Analytical Chemistry
- ☐ Biochemistry
- ☐ Inorganic Chemistry
- ☐ Organic Chemistry
- ☐ Physical Chemistry
- ☐ Other chemistry beyond the general/introductory level

Q3.9 Did you complete any of the following types of physics courses at the undergraduate or graduate level? [Select one on each row.]

	Yes	No
General/introductory physics courses (for example: Physics I, Introduction to Physics)	○	○
Physics courses beyond the general/introductory level	○	○
Physics education courses	○	○

Answer If *Did you complete any of the following types of physics courses at the undergraduate or graduate level? Physics courses beyond the general/introductory level* - Yes Is Selected

Q3.10 Please indicate which of the following physics courses you completed (beyond a general/introductory course) at the undergraduate or graduate level. [Select all that apply.]

☐ Electricity and Magnetism
☐ Heat and Thermodynamics
☐ Mechanics
☐ Modern or Quantum Physics
☐ Nuclear Physics
☐ Optics
☐ Other physics beyond the general/introductory level

Q3.11 Did you complete any of the following types of Earth/space science courses at the undergraduate or graduate level? [Select one on each row.]

	Yes	No
General/introductory Earth/space science courses (for example: Earth Science I, Introduction to Earth Science)	○	○
Earth/space science courses beyond the general/introductory level	○	○
Earth/space science education courses	○	○

Answer If *Did you complete any of the following types of Earth/space science courses at the undergraduate or graduate level? Earth/space science courses beyond the general/introductory level* - Yes Is Selected

Q3.12 Please indicate which of the following Earth/space science courses you completed (beyond a general/introductory course) at the undergraduate or graduate level. [Select all that apply.]

☐ Astronomy
☐ Geology
☐ Meteorology
☐ Oceanography
☐ Physical Geography
☐ Other Earth/space science beyond the general/introductory level

Q3.13 Did you complete any of the following types of environmental science courses at the undergraduate or graduate level? [Select one on each row.]

	Yes	No
General/introductory environmental science courses (for example: Environmental Science I, Introduction to Environmental Science)	○	○
Environmental science courses beyond the general/introductory level	○	○
Environmental science education courses	○	○

Answer If *Did you complete any of the following types of environmental science courses at the undergraduate or graduate level? Environmental science courses beyond the general/introductory level* - Yes Is Selected

Q3.14 Please indicate which of the following environmental science courses you completed (beyond a general/introductory course) at the undergraduate or graduate level. [Select all that apply.]

☐ Conservation Biology
☐ Ecology
☐ Forestry
☐ Hydrology
☐ Oceanography
☐ Toxicology
☐ Other environmental science beyond the general/introductory level

Q3.15 Did you complete one or more engineering courses at the undergraduate or graduate level?

○ Yes
○ No

Answer If *Did you complete one or more engineering courses at the undergraduate or graduate level?* Yes Is Selected

Q3.16 Please indicate which of the following types of engineering courses you completed at the undergraduate or graduate level. [Select all that apply.]

☐ Aerospace Engineering
☐ Bioengineering/Biomedical Engineering
☐ Chemical Engineering
☐ Civil Engineering
☐ Computer Engineering
☐ Electrical Engineering
☐ Industrial/Manufacturing Engineering
☐ Mechanical Engineering
☐ Other types of engineering courses

Q3.17 Which of the following best describes your teacher certification program?

- ○ An undergraduate program leading to a bachelor’s degree and a teaching credential
- ○ A master's program that also awarded a teaching credential
- ○ A post-baccalaureate credentialing program (no master’s degree awarded). Please explain. ____________________
- ○ You did not have any formal teacher preparation. Please explain. ____________________

Q3.18 In the last five years has your school or district participated in any STEM initiatives?

- ○ Yes
- ○ No

Answer If *In the last five years has your school or district participated in any STEM initiatives?* Yes Is Selected

Q3.19 Please describe the STEM initiatives that your school or district has participated in. What years? Who sponsored the initiative? Did the initiative have a name or can you describe the initiative?

Q3.20 When did you last participate in professional development (sometimes called in-service education) focused on science or science teaching? (Include attendance at professional meetings, workshops, and conferences, as well as professional learning communities/lesson studies/teacher study groups. Do not include formal courses for which you received college credit or time you spent providing professional development for other teachers.)

- ○ In the last 3 years
- ○ 4-6 years ago
- ○ 7-10 years ago
- ○ More than 10 years ago
- ○ Never

Answer If *When did you last participate in professional development (sometimes called in-service education) focused on science or science teaching? In the last 3 years* Is Selected

Q3.21 In the last 3 years have you… [Select one on each row.]

	Yes	No
attended a workshop on science or science teaching?	○	○
attended a national, state, or regional science teacher association meeting?	○	○
participated in a professional learning community/lesson study/teacher study group focused on science or science teaching?	○	○

Answer If *When did you last participate in professional development (sometimes called in-service education) focused on science or science teaching? In the last 3 years* Is Selected

Q3.22 What is the total amount of time you have spent on professional development in science or science teaching in the last 3 years? (Include attendance at professional meetings, workshops, and conferences, as well as professional learning communities/lesson studies/teacher study groups. Do not include formal courses for which you received college credit or time you spent providing professional development for other teachers.)

○ Less than 6 hours
○ 6-15 hours
○ 16-35 hours
○ More than 35 hours

Answer If *When did you last participate in professional development (sometimes called in-service education) focused on science or science teaching? In the last 3 years* Is Selected

Q3.23 Thinking about all of your science-related professional development in the last 3 years, to what extent do each of the following statements describe your experiences? [Select one on each row.]

	Not at all	To a limited Extent	To a Moderate Extent	To a Considerable Extent	To a Great Extent
You had opportunities to engage in science investigations.	○	○	○	○	○
You had opportunities to examine classroom artifacts (for example: student work samples).	○	○	○	○	○
You had opportunities to try out what you learned in your classroom and then talk about it as part of the professional development.	○	○	○	○	○
You worked closely with other science	○	○	○	○	○

teachers from your school.					
You worked closely with other science teachers who taught the same grade and/or subject whether or not they were from your school.	○	○	○	○	○
The professional development was a waste of your time.	○	○	○	○	○

Q3.24 When did you last take a formal course for college credit in each of the following areas? Do not count courses for which you received only Continuing Education Units. [Select one on each row.]

	In the last 3 years	4-6 years ago	7-10 years ago	More than 10 years ago	Never
Science	❍	❍	❍	❍	❍
How to teach science	❍	❍	❍	❍	❍
Student teaching in science	❍	❍	❍	❍	❍
Student teaching in other subjects	❍	❍	❍	❍	❍

Answer If *When did you last participate in professional development... In the last 3 years* Is Selected Or *When did you last take a formal course for college credit... Science - In the last 3 years* Is Selected Or *When did you last take a formal course for college credit... How to teach science - In the last 3 years* Is Selected

Q3.25 Considering all the opportunities to learn about science or the teaching of science (professional development and coursework) in the last 3 years, to what extent do each of the following statements reflect the extent to which an importance was placed on each of the following? [Select one on each row.]

	Not at All	To a Limited Extent	To a Moderate Extent	To a Considerable Extent	To a Great Extent
Deepening your own science content knowledge	○	○	○	○	○
Learning about difficulties that students may have with particular science ideas and procedures	○	○	○	○	○
Finding out what students think or already know about the key science ideas prior to instruction on those ideas	○	○	○	○	○
Implementing the science textbook/module to be used in your classroom	○	○	○	○	○
Planning	○	○	○	○	○

instruction so students at different levels of achievement can increase their understanding of the ideas targeted in each activity					
Monitoring student understanding during science instruction	❍	❍	❍	❍	❍
Providing enrichment experiences for gifted students	❍	❍	❍	❍	❍
Providing alternative science learning experiences for students with special needs	❍	❍	❍	❍	❍
Teaching science to English-language learners	❍	❍	❍	❍	❍
Assessing student understanding at the conclusion of instruction on	❍	❍	❍	❍	❍

a topic					

Answer If *At what grade levels do you currently teach science? K-5* Is Selected
Q3.26 Many teachers feel better prepared to teach some subject areas than others. How well prepared do you feel to teach each of the following subjects at the grade level(s) you teach, whether or not they are currently included in your teaching responsibilities? [Select one on each row.]

	Not Adequately Prepared	Somewhat Prepared	Fairly well Prepared	Very well Prepared
Life Science	○	○	○	○
Earth Science	○	○	○	○
Physical Science	○	○	○	○
Engineering	○	○	○	○
Mathematics	○	○	○	○
Reading/Language Arts	○	○	○	○
Social Studies	○	○	○	○

Q3.27 How prepared do you feel to implement each of the following in your science instruction? [Select one on each row.]

	Not Adequately Prepared	Somewhat Prepared	Fairly Well Prepared	Very Well Prepared
Plan instruction so students at different levels of achievement can increase their understanding of the ideas targeted in each activity	○	○	○	○
Teach science to students who have learning disabilities	○	○	○	○
Teach science to students who have physical disabilities	○	○	○	○
Teach science to English-language learners	○	○	○	○
Provide enrichment experiences for gifted students	○	○	○	○
Encourage students' interests in science and/or	○	○	○	○

engineering				
Encourage participation of females in science and/or engineering	○	○	○	○
Encourage participation of racial or ethical minorities in science and/or engineering	○	○	○	○
Encourage participation of students from low socioeconomic backgrounds in science and/or engineering	○	○	○	○
Manage classroom discipline	○	○	○	○

Q4.1 Programs and Practices

Q4.2 To the best of your ability, indicate which of the following programs and practices are currently being implemented in your school at each grade-level:

	K	1	2	3	4	5
Students in self-contained class receive science instruction from their regular classroom teacher.	☐	☐	☐	☐	☐	☐
Students in self-contained class receive science instruction from another teacher at the same grade-level.	☐	☐	☐	☐	☐	☐
Students in self-contained class receive science instruction from a science	☐	☐	☐	☐	☐	☐

specialist instead of their regular teacher.						
Students in self-contained class receive science instruction from a science specialist in addition to their regular classroom teacher.	☐	☐	☐	☐	☐	☐
Students are not in self-contained classrooms, they have specialist teachers for each subject, including science.	☐	☐	☐	☐	☐	☐

Q82 To the best of your ability, indicate which of the following programs and practices are currently being implemented in your school at each grade-level:

	K	1	2	3	4	5
Students in self-contained classes are pulled out for remediation in science.	☐	☐	☐	☐	☐	☐
Students in self-contained classes are pulled out for enrichment in science.	☐	☐	☐	☐	☐	☐
Students in self-contained classes are pulled out from science instruction for additional instruction in other content areas.	☐	☐	☐	☐	☐	☐

Q4.3 Do you have control over each of the following aspects of science instruction in your class(es)?

	No control	Little Control	Moderate Control	Considerable Control	Strong Control
Determining course goals and objectives	○	○	○	○	○
Selection textbooks/modules	○	○	○	○	○
Selecting content, topics, and skills to be taught	○	○	○	○	○
Selecting teaching techniques	○	○	○	○	○
Determining the amount of homework to be assigned	○	○	○	○	○
Choosing criteria for grading student performance	○	○	○	○	○

Q4.4 Think about your plans for your class for the entire year. By the end of the year, how much importance will you place on each of the following student objectives? [Select one on each row]

	Inhibits effective instruction	Of Little Importance in promoting effective instruction	Moderately Important in promoting effective instruction	Important in promoting effective instruction	Very Important in promoting science instruction
Memorizing science vocabulary and/or facts	○	○	○	○	○
Understanding science concepts	○	○	○	○	○
Learning science process skills (for example: observing, measuring)	○	○	○	○	○
Learning about real-life applications of science	○	○	○	○	○
Increasing students' interest in science	○	○	○	○	○
Preparing students for further study in science	○	○	○	○	○

Learning test taking skills/strategies	○	○	○	○	○

Q4.5 Please indicate how often you use the following practices during your science instruction. [Select one on each row.]

	Never	Rarely (A few times per year)	Sometimes (Once or twice per month)	Often (Once or twice a week)	All or Almost all science classes
Placing students in classes with students of similar abilities.	○	○	○	○	○
Focusing on ideas in depth, even if that means covering fewer topics.	○	○	○	○	○
Providing students with the purpose for a lesson as it begins.	○	○	○	○	○
Providing students with definitions for new scientific vocabulary that will be used at the beginning of instruction.	○	○	○	○	○
Explaining an idea to students	○	○	○	○	○

before having them consider evidence that relates to the idea.					
Reviewing previously covered ideas and skills during each class period.	○	○	○	○	○
Providing opportunities for students to share their thinking and reasoning each class period.	○	○	○	○	○
Providing hands-on/laboratory activities primarily to reinforce a science idea that the students have already learned.	○	○	○	○	○
Assigning students homework most days.	○	○	○	○	○
Providing	○	○	○	○	○

concrete experiences before abstract experiences.					
Developing students' conceptual understanding of a subject.	○	○	○	○	○
Engaging students in applications of subject matter in a variety of contexts.	○	○	○	○	○

Q4.6 Please rate the following on their importance of influence on your science instruction. [Select one on each row].

	Inhibits effective instruction	Of Little Importance in promoting effective instruction	Moderately Important in promoting effective instruction	Important in promoting effective instruction	Very important in promoting effective instruction
Idaho Content Standards in Science	○	○	○	○	○
Common Core State Standards	○	○	○	○	○
Next Generation Science Standards	○	○	○	○	○
District Curriculum Frameworks	○	○	○	○	○
District Pacing Guides	○	○	○	○	○
State science testing and accountability policies	○	○	○	○	○
District testing and accountability policies	○	○	○	○	○
Textbook/module selection policies	○	○	○	○	○
Students' motivation,	○	○	○	○	○

interests, and effort in science					
Students' reading abilities	○	○	○	○	○
Community views on science instruction	○	○	○	○	○
Parent expectations and involvement	○	○	○	○	○
Principal support	○	○	○	○	○
Time for you to plan, individually and with colleagues	○	○	○	○	○
Time available for your professional development	○	○	○	○	○

Q4.7 Think about your science instruction, identify the practices that you use in your science instruction (based on real-life constraints)? [Select one on each row].

	Never	Rarely (Few times a Year)	Sometimes (One to two times a month)	Often (Once or twice a week)	All or Most all Science Lessons
Taking students' prior understanding of a subject matter into account when planning curriculum and instruction	○	○	○	○	○
Engaging the whole class in discussions	○	○	○	○	○
Having students work in small groups	○	○	○	○	○
Doing hands-on/laboratory activities	○	○	○	○	○
Engaging the class in project-based learning (PBL) activities	○	○	○	○	○
Making connections to other disciplines	○	○	○	○	○

Having students read from a science textbook, module, or other science-related material in class, either aloud or to themselves	○	○	○	○	○
Having students represent and/or analyze data using tables, charts, or graphs	○	○	○	○	○
Requiring students to supply evidence in support of their claims	○	○	○	○	○
Having students make formal presentations to the rest of the class (for example: on individual or group projects)	○	○	○	○	○
Having students write	○	○	○	○	○

their reflections (for example: in their journals) in class or for homework					
Giving tests and/or quizzes that are predominantly short-answer (for example: multiple choice, true/false, fill in the blank)	○	○	○	○	○
Giving tests and/or quizzes that include constructed-response/open-ended items	○	○	○	○	○
Focusing on literacy skills (for example: informational reading or writing strategies)	○	○	○	○	○
Having students practice for standardized tests	○	○	○	○	○
Having	○	○	○	○	○

students attend presentations by guest speakers focused on science and/or engineering in the workplace					

Q4.8 Does your school provide the following to enhance students’ interests or achievement in science or engineering?

	Yes	No
a) Holds a family science and/or engineering night	○	○
b) Offers after-school help in science and/or engineering (for example: tutoring)	○	○
c) Offers one or more science/engineering clubs	○	○
e) Participates in local or regional science and/or engineering fair	○	○
f) Has one or more teams participating in science/engineering competitions (for example: Science Olympiad, Robotics, Future City)	○	○
g) Encourages students to participate in science and/or engineering summer programs or camps offered by community colleges, universities, museums, or science centers	○	○
h) Sponsors visits to business, industry, and/or research sites related to science and/or engineering	○	○
i) Sponsors meetings with adult mentors who work in science and/or engineering	○	○

fields		

Q4.9 Science courses may benefit from availability of particular kinds of items or facilities. What is the availability of the following items in your school? [Select one in each row]

	Not available	Limited availability (Present but not available for use)	Somewhat Adequate (Available, but quantities or location makes coordinating use challenging)	Nearly Adequate (In classroom, but limited quantities)	Adequate (In classroom in recommended quantities)
Equipment (microscopes, beakers, etc.)	○	○	○	○	○
Instructional technology (calculators, computers, tablets, probeware, etc.)	○	○	○	○	○
Consumable items (chemicals, living organisms, batteries, etc.)	○	○	○	○	○
Facilities (lab tables, electrical outlets, facets and sinks, etc.)	○	○	○	○	○

Q4.10 Indicate how often the following instructional items are available for use in your class? [Select one on each row]

	Never	Rarely (A few times per year)	Sometimes (Once or twice a month)	Often (Once or twice a week)	All or Almost all Science Classes
Personal computers, including laptops	○	○	○	○	○
Hand-held computers (PDAs, tablets, iPod touches, iPads)	○	○	○	○	○
Internet access	○	○	○	○	○
Probes for collecting data (example: motion sensors, temperature probes)	○	○	○	○	○
Microscopes	○	○	○	○	○
Classroom response system or "clickers" (handheld devices used to respond electronically	○	○	○	○	○

to questions in class)					
Calculators	○	○	○	○	○
Simple balances	○	○	○	○	○
Triple beam balances	○	○	○	○	○
liquid measurement tools (graduate cylinders, beakers, etc.)	○	○	○	○	○

Q4.11 Which best describes the instructional materials students most frequently use in your class?

- ○ Mainly one commercially-published textbook
- ○ Multiple commercially-published textbooks
- ○ Mainly commercially-published modules from one publisher
- ○ Mainly commercially-published modules form multiple publishers
- ○ A roughly equal mix of commercially-published textbooks and commercially-published modules
- ○ Non-commercially-published materials

Q4.12 The next set of questions will ask you about the last science unit you taught:

Answer If Which best describes the instructional materials students most frequently use in your class? *Non-commercially-published materials most of the time* Is Not Selected

Q4.13 Please indicate the title, author, most recent copyright year, and ISBN code of the textbook/module used most often (or most recently) by the students in this class.• The 10- or 13-character ISBN code can be found on the copyright page and/or the back cover of the textbook/module.• Do not include the dashes when entering the ISBN.• An example of the location of the ISBN is shown to the right.

Title:
First Author:
Year:
ISBN:

Answer If *Which best describes the instructional materials students... Mainly multiple commercially-published textbooks Is Selected Or Which best describes the instructional materials students... Mainly commercially-published modules form multiple publishers Is Selected Or Which best describes the instructional materials students... A roughly equal mix of commercially-published textbooks and commercially-published modules most of the time* Is Selected

Q4.14 Please indicate the title, author, most recent copyright year, and ISBN code of the second textbook/module used most often (or most recently) by the students in this class.• The 10- or 13-character ISBN code can be found on the copyright page and/or the back cover of the textbook/module.• Do not include the dashes when entering the ISBN.• An example of the location of the ISBN is shown to the right.

Title:
First Author:
Year:
ISBN:

Answer If Which best describes the instructional materials students most frequently use in your class?Non-commercially-published materials most of the time Is Not Selected

Q4.15 Think about the last science unit you taught. Indicate the importance of each of the following while teaching this unit. [Select one on each row.]

	Inhibits effective instruction	Of Little Importance in promoting effective instruction	Moderately Important in promoting effective instruction	Important in promoting effective instruction	Very Important in promoting effective instruction
Using the textbook/module to guide the overall structure and content emphasis of the unit.	○	○	○	○	○
Following the textbook/module to guide the detailed structure and content emphasis of the unit.	○	○	○	○	○
Picking out what is important from the textbook/module and skipped the rest.	○	○	○	○	○
Incorporating activities (for example: problems, investigations, readings) from other sources to supplement	○	○	○	○	○

what the textbook/module was lacking.					

Answer If *Think about the last science unit you taught. Indicate ... Picking out what is important from the textbook/module and skipped the rest. - Of Little Importance Is Selected Or Think about the last science unit you taught. Indicate ... Picking out what is important from the textbook/module and skipped the rest. - Moderately Important Is Selected Or Think about the last science unit you taught. Indicate ... Picking out what is important from the textbook/module and skipped the rest. - Important Is Selected Or Think about the last science unit you taught. Indicate ... Picking out what is important from the textbook/module and skipped the rest. - Very Important* Is Selected

Q4.16 During the last unit you taught, when you skipped activities (example: problems, investigations, readings) in your textbook/module, where any of the following factors in your decision? [Select one on each row]

	Yes	No
The science ideas addressed in the activities you skipped are not included in your pacing guide and/or current state standards.	○	○
You did not have the materials needed to implement the activities you skipped.	○	○
The activities you skipped were too difficult for your students.	○	○
Your students already knew the science ideas or were able to learn them without the activities you skipped.	○	○
You have different activities for those science ideas that work better than the ones you skipped.	○	○

Q4.17 During this unit, when you supplemented the textbook/module with additional activities, were any of the following factors in your decisions? [Select one on each row.]

	Yes	No
Pacing guide indicated you should use supplemental activities	○	○
Supplemental activities were needed to prepare students for standardized tests.	○	○
Supplemental activities were needed to provide students with additional practice.	○	○
Supplemental activities were needed so students at different levels of achievement could increase their understanding of the ideas targeted in each activity.	○	○

Q5.1 Instructional Leadership

Q5.2 In the last 3 years have you… [Select one on each row.]

	Yes	No
received feedback about your science teaching from a mentor/coach formally assigned by the school or district/diocese?	○	○
served as a formally-assigned mentor/coach for science teaching? (Please do not include supervision of student teachers.)	○	○
supervised a student teacher in your classroom?	○	○
taught in-service workshops on science or science teaching?	○	○
led a professional learning community/lesson study/teacher study group focused on science or science teaching?	○	○

Q5.3 How often during this school year has each of the following occurred?

	Never	Rarely (a few times per year)	Sometimes (Once or twice a month)	Often (Once or twice a week)	Always (100% of the occurrences, or more often than once or twice a week)
Your school administrator discussed instructional issues with you?	○	○	○	○	○
Your school administrator observe your classroom instruction?	○	○	○	○	○
Your school administrator made suggestions to improve classroom behavior or classroom management?	○	○	○	○	○
Your school administrator attended teacher planning meetings?	○	○	○	○	○
Your school administrator	○	○	○	○	○

gave you specific ideas for how to improve your instruction?					
Your school administrator protected teachers from distractions to their instruction?	○	○	○	○	○
Your school administrator clearly defined standards for instructional practices.	○	○	○	○	○

Q5.4 How often do each of the following occur in your school?

	Never	Rarely (a few times per year)	Sometimes (Once or twice a month)	Often (Once or twice a week)	Always (100% of the occurrences, or more often than once or twice a week)
Teachers influence how money is spent in this school	❍	❍	❍	❍	❍
Teachers have an effective role in school-wide decision making.	❍	❍	❍	❍	❍
Teachers have significant input into plans for professional development and growth.	❍	❍	❍	❍	❍
Your school's principal ensures wide participation in decisions about school improvement.	❍	❍	❍	❍	❍
Students have a direct	❍	❍	❍	❍	❍

influence on school decisions.					
School teams (depts., grade levels, other teacher groups) have influence on school decisions?	❍	❍	❍	❍	❍

Q5.5 During this school year have you been observed and received feedback on science instruction?

	Yes	No
Observed during formal observation	❍	❍
Observed during an informal or walk through observation	❍	❍
Received specific feedback on your science instruction.	❍	❍
Received specific feedback on reform-minded science practices (for example inquiry, the learning cycle, evidence based responses, etc.)	❍	❍

Answer If *During this school year have you been observed and receive... Observed during formal observation* - Yes Is Selected Or *During this school year have you been observed and receive... Observed during an informal or walk through observation* - Yes Is Selected

Q5.6 How many times have you been observed during science instruction this school year?

______ a) During a formal observation
______ b) During an informal or walk through observation

Q5.7 Do any of the following individuals provide science-focused one-on-one coaching in your school?

	Yes	No
a) The principal of your school	○	○
b) An assistant principal at your school	○	○
c) District administrators including science supervisors/coordinators	○	○
d) Teachers/coaches who do not have classroom teaching responsibilities	○	○
e) Teachers/coaches who have part-time classroom teaching responsibilities	○	○
f) Teachers/coaches who have full-time classroom teaching responsibilities	○	○

Q5.8 My school's principal makes an effort to monitor student progress in science? If yes, give an example.

○ Yes ____________________
○ No

Q6.1 Assessment

Q6.2 Do you use the following assessment strategies in science?

	Yes	No
a) Diagnostic assessments to determine prior knowledge and misconceptions.	○	○
b) Formative or embedded assessment to make informed decisions about their teaching, to adjust the rate of instruction, assign remediation activities, and plan alternative experiences.	○	○
c) Summative assessments, such as end of unit exams.	○	○
d) Performance assessment that allow students to demonstrate their abilities.	○	○
e) Use of science notebooks	○	○
g) Student self-assessment	○	○
h) Assessments aligned to district or state standards	○	○

Q6.3 Do you make the following changes in whole class science instruction based on data:

	Yes	No
a) Change lesson plans to place more emphasis in areas in which the class scores low.	○	○
b) Add more projects and exercises in areas in which the class scored low.	○	○
c) Request additional supplies or equipment.	○	○
d) Re-evaluate textbooks and learning materials.	○	○
e) Discuss curriculum relevance and alignment with standards and assessment with peers.	○	○
f) Ask for additional support and ideas from other teachers or administrators	○	○

Q6.4 Do you make the following changes in individual student science instruction based on data:

	Yes	No
a) Provide students with additional assistance during class in areas in which they performed poorly	○	○
b) Provide students with additional assistance outside of class in areas in which they performed poorly	○	○
c) Provide poorly performing students with materials on test-taking skills and strategies	○	○
d) Provide high-performing students with additional, more challenging projects and/or readings.	○	○

Q6.5 The next set of questions will ask you about the last science unit you taught:

Q6.6 How well prepared did you feel to do each of the following as part of your instruction on this particular unit? [Select one on each row.]

	Not adequately prepared	Somewhat prepared	Fairly well prepared	Very well prepared
Anticipate difficulties that students may have with particular science ideas and procedures in this unit	○	○	○	○
Find out what students thought or already knew about the key science ideas	○	○	○	○
Implement the science textbook/module to be used during this unit	○	○	○	○
Monitor student understanding during this unit	○	○	○	○
Assess student understanding at the conclusion of this unit	○	○	○	○

Q6.7 Which of the following did you do during the unit?

	Yes	No
Administered an assessment, task, or probe at the beginning of the unit to find out what students thought or already knew about the key science ideas	○	○
Questioned individual students during class activities to see if they were “getting it”	○	○
Used information from informal assessments of the entire class (for example: asking for a show of hands, thumbs up/thumbs down, clickers, exit tickets) to see if students were “getting it”	○	○
Reviewed student work (for example: homework, notebooks, journals, portfolios, projects) to see if they were “getting it”	○	○
Administered one or more quizzes and/or tests to see if students were “getting it”	○	○
Had students use rubrics to examine their own or their classmates’ work	○	○
Assigned grades to student work (for example: homework, notebooks,	○	○

journals, portfolios, projects)		
Administered one or more quizzes and/or tests to assign grades	○	○
Went over the correct answers to assignments, quizzes, and/or tests with the class as a whole	○	○

Q7.1 Conclusion

Q79 Please describe how you implement elementary science into your curriculum:

Q7.2 This is your opportunity to tell me about your school. Why do you believe that your elementary school has been so successful at consistently attaining high-achievement in elementary science education?

APPENDIX D

IRB Approval

BOISE STATE UNIVERSITY

DIVISION OF RESEARCH & ECONOMIC DEVELOPMENT
Office of Research Compliance
Institutional Review Board
humansubjects@boisestate.edu | (phone) 208.426.5401 | MS 1138

DATE: November 7, 2013

TO: Jill K. Hettinger (PI)
Ted Singletary (co-PI)

FROM: Office of Research Compliance
Institutional Review Board (IRB)

SUBJECT: IRB Notification of Approval
Project Title: *Finding Success in Elementary Science Across Socioeconomic Boundaries*

The Boise State University IRB has approved your protocol application. Your protocol is in compliance with this institution's Federal Wide Assurance (#0000097) and the DHHS Regulations for the Protection of Human Subjects (45 CFR 46).

Review Type: , Category#7	**Approval Number: 107-SB13-103**
Date of Approval: November 7, 2013	**Expiration Date: November 6, 2014**

Your approval is effective for 12 months. If your research is not finished within the allotted year, the protocol must be renewed before expiration date indicated above. The Office of Research Compliance will send a reminder notice approximately 30 days prior to the expiration date. The principal investigator has the primary responsibility to ensure a RENEWAL FORM is submitted in a timely manner. If the protocol is not renewed before the expiration date, a new protocol application must be submitted for IRB review and approval.

Under BSU regulations, each protocol has a three-year life cycle and is allowed two annual renewals. Please note that if your research is not complete by November 6 , 2016, a new protocol application must be submitted, rather than a third annual renewal form.

All additions or changes to your approved protocol must also be brought to the attention of the IRB for review and approval before they occur. Complete and submit a MODIFICATION FORM indicating any changes to your project. When your research is complete or discontinued, please submit a FINAL REPORT FORM. An executive summary or other documents with the results of the research may be included.

All relevant forms are available online. If you have any questions or concerns, please contact the Office of Research Compliance, 208-426-5401 or humansubjects@boisestate.edu.

Thank you and good luck with your research.

Jaime Sand

Jaime Sand
Chairperson
Boise State University Social & Behavioral Institutional Review Board