On the Consideration of Adoption and Implementation of The Next Generation Science Standards in a Local-Control Context: Supporting the Epistemology of Science through Education Policy

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ABSTRACT

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The primary purpose of this research is to understand how and why members at each of the three levels of the education system within a local-control state made the decisions they did in supporting or hindering the adoption and implementation of the Next Generation Science Standards. This research concentrates on three levels of the education system in a local-control state; 1) the state level, 2) the district level, and 3) the school/teacher level, while investigating the following questions:

1. To what extent, and in what ways, do members in each of the three levels of the state education system advocate for adoption and implementation of the Next Generation Science Standards?
2. Are the members in each of the three levels motivated or compelled to consider adoption and implementation of the Next Generation Science Standards, why or why not?
3. To what extent, and in what ways, do the members in each of the three levels take into account science epistemology in their overall consideration of adoption/implementation of the NGSS?

The data drew from a series of interviews from a prior study, "*Challenges of Implementing the Next Generation Science Standards in Local-Control States in the U.S."* (Sevian, Foster, & Scheff, 2012).

After these data were coded and analyzed around the three research questions, this phenomenographic research study identified four key findings:

Key Finding 1 - As the District Coordinators are uniquely situated within the state education system to be able to see both the on-the-ground practical implications and the high-level policy pressures of adopting and implementing the NGSS, they reflect the deepest level of awareness of how to best advocate for adoption and implementation of the NGSS.

Key Finding 2 - Motivation to adopt and implement the NGSS is highly nuanced. The most significant factor influencing motivation to adopt or implement the NGSS at each level is related to assessment. The reasons assessment affects motivation is different at each level.

Key Finding 3 - Each interviewee at each level demonstrated awareness that the NGSS are significantly different from prior standards in some way. While teachers and SSCs sometimes cited the science practices as the critical difference, they were not able to meaningfully elaborate on what "science practices" are. Conversely, the District Coordinators demonstrated a deeper level of awareness and were able to comment more specifically on the practices and how they would affect science education in their state.

Key Finding 4 - Regardless of level, the better a participant reflected an awareness of epistemology, the more likely they were to advocate for adoption and implementation of the NGSS. Similarly, the better a participant reflected an awareness of epistemology, the more likely they were motivated to consider adoption and implementation of the NGSS.

The implications of the findings in this current study can; inform the supplemental materials and dissemination of information by standards writers, help policy makers engage stakeholders appropriately at each level by illustrating how national reform efforts play out in local-control states, and aid school based employees by identifying how and where they can participate in state level policy discussion and where their input could be valuable.

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CHAPTER ONE:
Introduction

On July 19, 2011 the National Research Council (NRC) published *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. This document is intended to represent, "the first step in a process to create new standards in K-12 science education" (NRC, 2011a, p. viii). Achieve, Inc., a Washington based non-profit education reform organization, has translated the NRC document into a clearly articulated set of performance based science standards, which is called *The Next Generation Science Standards* (NGSS). While being a separate effort, the NGSS are a complement to the *Common Core State Standards* effort in English language arts and mathematics and are intended to serve as a set of new national standards for science education in the United States. While each state is already required to have educational standards in science and some question the aspirations of a nationally led standards-based reform movement, the impetus for redesigning science standards at the national level lies in the significant underperformance of American students on complex reasoning within science. This underperformance is most notable on international assessments, such as the Program for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS) (OECD, 2010). Even on domestic measures, such as the 2009 science portion of the National Assessment of Educational Progress (NAEP) only 21% of American students scored proficient or above. Other research has shown a sharp decline in the number of students pursuing college degrees in mathematics and science (Kirsch, Braun, Yamamoto, & Sum, 2007) and how students have become less likely to be motivated to continue taking science courses after all of their science requirements have been satisfied (Koalla & Glynn, 2007).

Despite these facts, significant advances in the theory and practices of learning in science and how to assess this learning have been made over the past 10 years; yet, how to successfully implement effective strategies to address this underperformance in science remains unclear (see, Duschl, Schweingruber & Shouse, 2007; NAEP, 2009; Kirsch et al., 2007).

Notwithstanding the political opposition from those that view education as the sole responsibility of the states, a number of groups have begun to call for higher standards to be set and measured at the national level (The Carnegie Corporation of New York and Institute for Advanced Study, 2009; NRC, 2011b; Weiss, Knapp, Hollweg, & Burrill, 2001). As this list of supporters for new national science standards has grown over the past few years, our understanding of the critical components that must be included to support students' deep level of understanding within the discipline has also evolved. What has not evolved is our understanding of effective policies to support these standards being translated into curricula, assessments, professional development and teacher training.

Purpose

The Framework and the NGSS provide a significant amount of guidance on how the scope and sequence of science content should be covered within a science classroom but ultimately it will be up to the states, school districts, curriculum developers, teachers and other stakeholders to determine how to interpret and integrate this into the overall learning environment for students. This research study focuses on how three levels of the education system within a local-control state – 1) the state level, 2) the district level, and 3) the school/teacher level – supports or hinders the adoption and implementation of the NGSS. This research also measures key understandings of members that represent each of these levels in terms of their goals for science education (i.e., what they hoped to accomplish with their decisions). In doing this, this study identifies how top-down and bottom-up efforts in local-control policy environments support the implementation of new standards.

The focus on local-control states highlights some of the most difficult implementation issues that large scale science education reform efforts face, specifically that a number of stakeholders are involved in the decision making process at various times and to varying degrees. Despite each state already having a set of science standards, which they have written, adopted, and implemented, there is a lack of educational research about *how* science standards are implemented within the state education system. For example, there is little research that exists

on how decisions are made in a local-control context, especially when it comes to considering change and adoption of new educational reforms. This lack of research is particularly notable when it comes to science education reform efforts, and what ultimately compels or motivates these stakeholders to consider a change or how much to change (McEver, 2010). Similarly, there is a dearth of information regarding how stakeholders working on major reform efforts in science education, specifically the NGSS in this case, navigate state, district, and school/teacher level policies. Also, not much is known about who the players are or how understandings, such as scientific epistemology, are transferred from one level to the next. Moreover, very little research has been conducted regarding the roles each of these stakeholders have in the final implementation reforms based off of educational research, such as the NGSS.

One of the most significant changes in the NGSS from previous standards efforts at the state level or national level is the outlining of the science practices and the integration of these practices into student level performance expectations. These practices – eight in all – outline how students should engage in the content of science and set a way of knowing within the discipline. As the NRC Framework (2011a) notes, "[e]ngaging in the practices of science helps students understand how scientific knowledge develops" (p. 3-1). The Framework goes on to state, "[science practice] makes students' knowledge more meaningful and embeds it more deeply into their world view" (NRC, 2011a, p. 3-1). The science practices are important because they are directly related to a deep understanding of what science is and they outline a framework for how science is used to create knowledge within the discipline. In this way, the science practices are directly related to understanding the epistemology of science.

Science epistemology, and the role science epistemology plays in the NGSS, is a major theme throughout this research study. The theoretical principles of science epistemology are presented in depth throughout chapter two, but the context and role science epistemology plays in the adoption and implementation process is what this study will focus on. The most significant difference between these standards and previous efforts, both at the state and national level, is this inclusion of science practices and the significance this places on the learning of science

epistemology. Given this, it is useful to understand the level of appreciation and/or awareness each stakeholder places on the role of science epistemology as they consider adoption and implementation of the NGSS.

This research explores the nuance regarding how reform is implemented and influenced in local-control policy environments. Further, this research describes what is, or is not, changing and how and why this change is occurring. This research study identifies key stakeholders that influence the overall policy environment and maps the constructive and destructive interferences within the system. This research is useful in providing recommendations for policymakers as it informs steps that can be taken to support large-scale change in local-control contexts. This research also helps to inform coordinated processes of top-down and bottom-up reform initiatives in local-control contexts.

While this research identifies major stakeholders and decision-maker's involved in the process of adoption and implementation of the NGSS, the primary purpose of this research is to understand why decision makers made the decision they did. To achieve this primary focus the research concentrates on three levels of the education system in a local control state; 1) the state level, 2) the district level, and 3) the school/teacher level. This investigation answers the following questions:

1. To what extent, and in what ways, do members in each of the three levels of the state education system advocate for adoption and implementation of the Next Generation Science Standards?
2. Are the members in each of the three levels motivated or compelled to consider adoption and implementation of the Next Generation Science Standards, why or why not?
3. To what extent, and in what ways, do the members in each of the three levels take into account science epistemology in their overall consideration of adoption/implementation of the NGSS?

Organization of the Dissertation

This dissertation is organized into five chapters. Chapter Two, Literature Review,

presents the theoretical framework and relevant literature around the history of science standards, science epistemology, and educational policy in the United States. This chapter also identifies the research questions that guide this dissertation. Chapter Three, methodology, presents a full description of the research methodology for this study. This includes the participants interviewed, how these interviews were conducted and the organization of the study participants. This chapter also describes all of the codes that were used in analyzing the data collected and provides descriptions and examples for each. Chapter Four describes the finding of this research at each of the three levels, the state, district, and school/teacher level. It also identifies four 'key findings' from this research and explores the similarities in the findings across the three levels as they relate to the research questions. Finally, the dissertation closes with Chapter five, which is a discussion of the findings as they relate to both the research questions and our current understanding of the literature outlined in chapter two. In addition, this chapter provides recommendations for future research, and discusses the generalizability of this type of a study.

Personal Perspective

My personal interest on this topic stems from my own work at the College Board constructing the *Science College Board Standards for College Success* (College Board, 2009) and the redesign of the Advanced Placement (AP) science courses and exams. In both of these projects the College Board laid out a specific set of science practices which refocus the content and purpose of the material in order to engage students in a greater understating of how scientific knowledge is constructed (i.e., the scientific epistemology). Since the publication of the *Science College Board Standards for College Success* and the AP redesign, I have begun to shift my focus to researching the NGSS effort. Given that I have been employed as the Director of Science Education with the College Board, I am uniquely situated to view this process of how states translate the NGSS from inception to implementation as they build or adapt policies to support this effort. Having worked on one standards document already, and being heavily involved with the AP redesign, I have come to realize that any attempt to change the current education system must be viewed as a stress on an already overburdened system. I see the

NGSS as a significant stress on the way we currently teach science in this country, and it is clear that the NGSS will require *newly conceived* policy support at several levels in order to be implemented with the original intent intact. Therefore, this work is not only relevant to my own interests, but the interests of anyone who is in support of seeing the NGSS finding its way into science classes around the country. While this research is not meant as a historical analysis of science education standards, it will examine the policy environment that effected the implementation of previous national standards efforts and how those standards have feed back into the system and contributed to the ongoing evolution of national education policy in science. By studying this evolution, this research will examine how science standards set at the national level can impact education policy at scale.

CHAPTER TWO:
Literature Review

This study focuses on several major constructs in education; science epistemology, science practices, the nature of science, and national and state education policy. As outlined in this chapter, there is an abundance of research that already exists which considers standards based reform movements in each of these constructs, yet a dearth of research exists relating how policy makers are influenced by their understanding of epistemology, especially in the field of science education.

History of Science Standards

While this study considers scientific epistemology, the primary construct on which this research focuses is based on how decision makers adjudicate supporting students' learning of scientific epistemology as they consider implementation of the NGSS. In order to better understand the evolution of scientific epistemology within science education policy, it is helpful to take a look back at how the concept of educational standards has been evolving in the United States over the past 30 years. The Gardner 1983 seminal report, *A Nation at Risk,* was one of the first national documents to call for a new breed of standards reform in science education. This report proposed linking accountability of states and schools to student assessment that was to be aligned to the reformed standards. To achieve this, the report called for higher "standards" in the five new basics: science, mathematics, English, social studies, and computer science (plus a foreign language for college-bound students) (NRC, 1983). Shortly after the NRC's report, the National Science Board came out with its own report titled, *Educating Americans for the 21st Century* (1983). In this report, the National Science Board outlined the most important topics students should know in the various science fields (Lazzaro, Luiser, Hamen, DeBoer, Songer, Ridky, 2010). The National Science Board's report helped pave the way for a 1989 congressional push that established clear national performance goals and strategies for K-12 education. Led by president George H.W. Bush's administration, along with the governors of each state, this effort led to an agreement that each state would give an annual report on its progress in meeting these

outlined goals in order to ensure that the United States would remain internationally competitive (DeBoer, 1991).

Also in 1989, the American Association for the Advancement of Science (AAAS) Project 2061 published its own report titled *Science for All Americans.* In terms of the evolution of science education and science standards, this document was key. *Science for All Americans* along with a 1993 document from AAAS titled *Benchmarks for Science Literacy* outlined a vision of science literacy for all and detailed what students, and ultimately all citizens, should know in science (AAAS, 1993). Then, in 1996 the NRC published the *National Science Education Standards*, which presented a, "vision of a scientifically literate populace. They outline what students need to know, understand, and be able to do to be scientifically literate at different grade levels" (p. 2). While none of these publications specifically called out the still emerging concept of "science practices," *Science for All Americans, Benchmarks for Science Literacy,* and *The National Science Education Standards* all included inquiry as a main focus of how science should be taught and learned. The National Science Education Standards state,

> The Standards call for more than 'science as process,' in which students learn such skills as observing, inferring, and experimenting. Inquiry is central to science learning. When engaging in inquiry, students describe objects and events, ask questions, construct explanations, test those explanations against current scientific knowledge, and communicate their ideas to others. They identify their assumptions, use critical and logical thinking, and consider alternative explanations. In this way, students actively develop their understanding of science by combining scientific knowledge with reasoning and thinking skills. (NRC, 1996, p. 2)

A few years after the publication of the *National Science Education Standards,* the Elementary and Secondary Education Act was reauthorized, and what was ultimately produced was the *No Child Left Behind Act (NCLB)* of 2001. NCLB significantly increased testing in math and English language arts and added repercussions for failure to meet performance goals;

however, it failed to include science assessments until 2007 (Lazzaro et al., 2009). Partly in response to the new focus on standards and partly in response to the fact that science was losing instructional time and resources to math and ELA, AAAS published a two-volume set titled, *Atlas of Science Literacy*. These Atlases reorganized the content of science in a way that allowed for a deeper understanding of the content by highlighting the connection of the topics from different disciplines. The Atlas books also contained scientific "skills," which highlighted the importance of not only the science content but also outlined processes for how scientists conduct science. Due to the explicit outlining of these skills by AAAS, many researchers and science educators felt that the skills had little value because they were taken out of context. In response to this decontextualization, the NRC published a seminal book titled, *Taking Science to School: Learning and Teaching Science in Grades K-8* (Duschl, Schweingruber and Shouse, 2007) which outlined how all students were to meet rising expectations for academic performance by integrating these skills within content to provide clear performance expectations for students. Many researchers and education policymakers consider this publication to be the emergence of science practices, as we know them today.

One of the first standards documents to incorporate this emerging vision of science practices was the Science College Board Standards for College Success (College Board, 2009). The Science College Board Standards for College Success served as an important document for the NGSS for three reasons. First, they were published just months before the NRC and Achieve Inc. announced the NGSS project so they contained some of the most recent research in science education. In addition, they served as a clear prototype for how this recent research on integrating practices and content to create multidimensional performance expectations could be successfully integrated into a large-scale standards document. Second, many of the committee members that worked on the College Board document transitioned over to the NGSS project, so there was a good deal of institutional knowledge overlap between the two efforts. Third, the NGSS needed to justify a benchmark for science college-readiness. The NGSS claim that they will prepare students for an introductory college level science course, but there is no standard for

what counts as a typical intro level science course. By citing the College Board document throughout the NGSS framework and standards document, the writers of the NGSS were able to claim alignment to the Advanced Placement® (AP) science courses and assessments, which is a product the College Board owns and is widely accepted by colleges and universities as equivalent to their introductory science courses.

Science Epistemology

Broadly speaking, scientific epistemology can be defined as a way of knowing science and viewing the world through a scientific lens (Duschl et al., 2007; Popper, 2002). However, as Sandoval (2003) notes, "there is no single consensus scientific epistemology that scientists, philosophers, and historians agree on. There are, however, several aspects regarding the nature of scientific knowledge and scientific work for which there is general agreement and that students arguably should understand" (p. 2). The NRC Framework (2011a) explicitly discusses this epistemology stating, "understanding how science functions requires a synthesis of content knowledge, procedural knowledge, and epistemic knowledge" (p. 3-22). The Framework offers a definition of epistemic knowledge as, "knowledge of the constructs and values that are intrinsic to science" (p. 3-22). In addition, the Framework clearly articulates a set of "Science Practices" which are intended to, "cultivate students' scientific habits of mind, develop their capabilities to engage in scientific inquiry, and teach them how to reason in a scientific context" (NRC, 2011a, p. 3-1). The following paragraphs outline the key characteristics and distinguishing features on how the epistemology of science is situated within an educational context, and how the Framework and NGSS plan to make use of this concept in a way that will facilitate better student understanding in science.

To frame a scientific epistemology and outline how the NGSS will make use of this epistemology, it is helpful to first discuss children's natural ways of constructing knowledge to emphasize the importance of learning the epistemology of science and to highlight the care necessary in conveying these ideas. Children already construct meaning from their lived experiences (Duschl et al., 2007), and they should learn science as another way of knowing with

its own epistemology and underlying assumptions. The NRC Framework (2011a) notes that children are innately curious and attempt to make sense of the world around them; and researchers have established that educational best practices should not view children's minds as blank slates to be filled with knowledge (Redish, 1994). Rather, children enter the classroom with a "great deal of knowledge" about the world around them formed from their everyday lived experiences (Hammer, 2000, p. S53). Considering this research, the NRC Framework (2011a) calls for a science education system that requires the integration of knowledge on how the natural world works and requires students to understand how this knowledge has changed over time, how it can be used as evidence in explaining accepted phenomena, and how it can be used to make predictions about the behavior or aspects of unknown phenomena.

Students must also be able to distinguish the epistemology of science from other ways of knowing in order to practice science and to assess the benefits, applications, and limitations of this form of knowledge (Hofer & Pintrich, 2002; Hammer & Elby, 2002). For instance, students should consider questions such as: How is a hypothesis tested? What counts as evidence? How is scientific knowledge constructed? The Framework (2011a) has carefully considered how these types of questions influence the core knowledge students should know and understand, and have devoted an entire strand of the Framework to outlining these in the form of science practices. The NRC's Framework calls for developing a deep understanding of "science as a way of knowing." This component is outlined in Strand 3 of the document, which states:

> Strand 3 focuses on students' understanding of science as a way of knowing. Scientific knowledge is a particular kind of knowledge with its own sources, justifications, ways of dealing with uncertainties, and agreed-on levels of certainty. When students understand how scientific knowledge is developed over systematic observations across multiple investigations, how it is justified and critiqued on the basis of evidence, and how it is validated by the larger scientific community, the students then recognize that science entails the search for core explanatory constructs and the connections between them. (NRC, 2011a, p.10-7)

Of course, how students internalize and use this "way of knowing" depends a lot on where they are in the development process. For example, it is easier for novice students, or students with little knowledge about a topic, to combine new information with his or her existing knowledge. This process is known as "assimilation" (Posner, Strike, Hewson & Gertzog, 1982). While it may be easier for a novice student to assimilate this knowledge, a child's mental models or conceptions about the world may contain contradictions and may be incorrect. How best to address these misconceptions is a topic of much debate within the education research community, but misconceptions or alternative models that children have must be considered in science education since researchers agree that changing these mental models becomes increasingly more difficult as a student becomes older (Redish, 1994). These difficulties exist because this type of change is not an isolated process but rather, it is influenced by personal, motivational, social, and historical factors (Pintrich, Marx, & Boyle, 1993). Researchers suggest that, rather than focusing on changing students' misconceptions, it is more effective to use correct aspects of students' mental models, or what Hammer refers to as intellectual "resources," to help students learn scientific concepts (Hammer, 2000, p. S53).

As students develop mental models and begin to make sense of the world around them, they do so from multiple ways of knowing. Hammer and Elby (2002) describe several examples of children's multiple epistemologies such as, invented knowledge (i.e., made-up), inferred knowledge, knowledge as direct perception and knowledge as inherent. Hammer and Elby (2002) also note that children will choose different epistemologies based on a particular context. For example, a student may draw on faith when considering certain philosophical questions or ideas but may choose to use empirical reasoning when in the science classroom. According to Hammer and Elby (2002), helping students learn science requires building upon children's pre-existing epistemological resources that are productive to learning science.

Underlying children's mental models and epistemologies are their worldviews. Cobern (1994) explains, "worldview provides a person with presuppositions about what the world is really like and what constitutes valid and important knowledge about the world" (p. 5). In other words, a

child's worldview determines what is to be learned. For a child to learn science, he or she must have a "scientifically compatible worldview" (Cobern, 1994, p. 5). Otherwise, the student will see learning science as unimportant, not useful, and irrelevant to his or her life and identity. This is a very important aspect of the overall intent of the NGSS. The NGSS is not simply outlining the content and practices but is also a way to motivate students learning through the process of scientific discovery. A scientifically incompatible worldview prevents students from constructing scientific knowledge in meaningful ways and therefore will hinder their development of a scientific epistemology.

To have students understand, accept and participate in science effectively, students must understand that science knowledge is not doctrine. Scientific knowledge is socially constructed and based on observations and inferences from the natural world. While science attempts to model reality, it is not itself reality. Johnson explains, "there is no way to know whether science is converging on a single truth, the way the universe really is, or simply building artificial structures, tools that allow us to predict, to extend, and to explain and control" (1995, p. 6). This is not meant to downplay the value and utility of scientific knowledge or a scientific epistemology. Instead, by including this as a component of science curriculum it helps facilitate students' engagement in science by highlighting how science is not a set of facts to be learned, but a process in which a community engages. When students are encouraged to think of science as a way of knowing and not a way of arriving at a set of conclusive answers they begin to see science as less absolute (Lederman, 2007).

Defining Science Practices

In most science education research, the term "science practices" is rarely defined. Instead, examples of science practices are used as ways to describe and express what is meant by a science practice. Duschl et al. (2007) describe three key features of science practices and how these science practices require "carefully crafted support and instruction" (p. 265). They state, "[a]s students wrestle with meaningful scientific problems they (1) engage in social interaction, (2) appropriate language of science, and (3) use science representations and tools" (p.

265). As Duschl et al. make clear throughout their book, science practices are not simply one thing that can easily be defined; rather, they are a description of a process, a set of approaches and a framework unto themselves that allows one to think scientifically. The reason for including these practices in the *Framework for K-12 Science Education* is that it allows students to deepen their conceptual understanding of the scientific content that is outlined in the document. The practices ensure that students adhere to working with the scientific content outlined in the document in a more authentic way, asking them to "practice" science in the same way that a scientist would. It requires that the content be organized and learned through the practices and not the other way around. For example, a student can learn about how substances exist naturally in three different states on earth, solid, liquid or gas, but this is very different from asking a student to, "use the small-particle model as evidence that supports the claim about the differences between [solids, liquids and gasses] in terms of the distance between particles, the movement of particles and the distribution of particles" (College Board, 2009, p. 110). This performance expectation from the Science College Board Standards for College Success (2009) highlights how the practices can be integrated with the content to facilitate students understanding of the content at a much deeper level.

It is important to understand that the practices outlined in the NGSS are not a simple set of unconnected skills. Instead, when taken collectively, these practices set up the way that scientific concepts come to be known as science. The practices are a common way of knowing within the disciplines of science (i.e., Life Science, Physical Science, Earth and Space Science), and serve as a framework for a scientific epistemology. These common practices within science are what set science apart from other ways of knowing, and begin to draw a boundary around this scientific epistemology. For the purpose of the NRC Framework document, these practices allow students to build the appropriate "habits of mind" that allow "students to engage in science content in ways that are similar to those used by scientists" (College Board, 2009, p. 5).

How the practices fit into the Framework

The science practices outlined in the Next Generation Science Standards (2012) are:

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

The committee then takes each of these practices and breaks them down further by providing a detailed description of what is meant by each practice, and how each practice is situated in the context of science and engineering. Because each of these practices can be achieved at various levels, for example, "using mathematics" could mean a student uses algebra or that a student uses differential equations to a solve a given problem, the committee also set goals for all students' to reach by the end of grade 12 for each of the practices. Included with these goals is a section labeled "progression," which outlines the ways in which each of these practices should be scaffolded as a student gets more exposure to working with each progression over the course of his or her K-12 school career. In science education, the term "progression" is conceptualized as evolving conceptual models that increase in sophistication over time. As Duncan and Rivet (2012) note, learning progressions associated with the NGSS should, "begin with consideration of learners' prior knowledge and build toward targeted learning goals through carefully designed instruction" (p. 396).

Assuming these standards are implemented with fidelity, this focus on the practices of science has the potential to significantly change the ways in which science education is taught and learned in the classroom. The level of detail the NRC has provided to the standards writers regarding practices allowed the standards writers to include detailed performance expectations that will go along with each of the content areas to be outlined. These performance expectations combine each content topic with a specific science practice in order to outline the observable

evidence that would indicate for a teacher that their student has a full understanding of a particular topic. Outlining performance expectations in this way does not prescribe a curriculum, but does articulate what students should know and be able to do by the end of each grade band. In addition, these performance expectations identify boundaries around content that is outside of the scope of that standard. This is done through the use of assessment boundaries and clarification statements that are linked to many of the performance expectations throughout the document.

Science Practices, Epistemology and the Nature of Science

For the purpose of this study, a distinction will be made among epistemology and the nature and practices of science. The epistemology of science can be defined as the scientific way of knowing. Knowledge construction in science, as is true in most domains, follows particular rules. These rules, for example, include how data can serve as evidence to support a claim, the process of validation through consensus, and the idea that scientific knowledge is tentative. Popper (1959) defines science epistemology, or what he prefers to call "the logic of scientific discovery," as a "set of rules" that, "should be identified with the theory of the scientific method" (p. 27). He goes on to state, "I propose to adopt such rules as will ensure the testability of the scientific statements; which is to say, their falsifiability" (Popper, 1959, p. 29). While it is important to realize that Popper's framing of science epistemology is dated, it does allow one to explore how the definition has evolved over the past 50 years. As the NRC stated in a recent report, "[i]f neither Bacon nor Popper nor Kuhn gives us a perfect description of what science is or how it works, all three of them help us to gain a much deeper understanding of it" (Goodstein, 2000, p. 43). It is this "deeper understanding," and in particular how this "deeper understanding" is imbedded into the NGSS, that is important to this research.

Science practices are different from science epistemology in that the practices are the *activities* scientists engage in to construct scientific knowledge, such as experimentation, data analysis, modeling, and argumentation. Practices are an evolution, as well as a way to operationalize, the early definition that Popper offer's for epistemology. Duschl (2008), describes

an early notion of the science practices that are now articulated in the NGSS and how these relate to the evolution of our understanding of scientific epistemology, “the important roles that guiding conceptions, evidence, and explanations have in framing the syntactic, semantic, and pragmatic structures of scientific inquiry, namely, the epistemic criteria, the conceptual clusters, and the experimental and knowledge-building practices used when doing science” (p. 276).

While the epistemology and practices of science are more clearly defined, there is less agreement regarding the nature of science (see; Alters, 1997; Osborne, Simon, & Collins, 2003). The nature of science is often defined as the values and assumptions underlying the scientific endeavor and how the scientific endeavor is, “inherent to scientific knowledge and the development of scientific knowledge” (Leaderman & Leaderman, 2004, p. 36). These assumptions are inherent throughout scientific research, and include principles such as patterns that exist in nature, an objective reality that exists outside of the observer, and natural phenomenon that can be measured and used to make predictions about the natural world. What the nature, epistemology, and practices of science all share is that they are all continuing to evolve with our understanding of science as a discipline, and with the ways in which society is served by the endeavor of science.

Attention in this study is paid to this particular notion of epistemology, and specifically how the practices outlined in the NGSS allow for studying epistemology. As stated in the NRC’s Framework for K-12 Science Education (2012), “[e]pistemic knowledge is knowledge of the constructs and values that are intrinsic to science. Students need to understand what is meant, for example, by an observation, a hypothesis, an inference, a model, a theory, or a claim and be able to distinguish among them ” (p. 79).

Education Policy in the United States

Educational policy in the United States is complex. While the Federal government and the US Department of Education do have significant influence over the education system, ultimately how students are educated and what plays out in the classroom are the purview of the states, and, in many cases, the local governing bodies where the schools reside. Historically

there has been a power struggle between the states and the federal government regarding where education policy decisions should be made. A similar power struggle can be observed within states between the state and local governments. Further complicating this system, are the many organizations that are national but not part of the federal system, which also influence educational policy and decision-making. Many of these national stakeholders provide services or products to the system (e.g., professional development for teachers, curriculum developers, assessment developers, teacher unions, etc.) that lie outside of the governing bodies, but absolutely control aspects of how children are educated within the system (Kingdon, & Thurber, 1984).

This particular study is focused on the state and local government policies in terms of adoption and implementation of the NGSS, and it is worth noting that the federal government played virtually no role in the development of the NGSS or in advocating for adoption by the states, districts, or schools. It should also be noted that while we can say that this is not a federal issue, there were many national players that contributed to the conversation. The privately owned and operated Carnegie Corporation of New York funded the development of the project, and the framework and standards themselves were managed by the National Research Council's Board on Science Education (BOSE) and Achieve Inc. respectively (NGSS Website, 2013). Due to the federal government's hands-off approach to the NGSS, policy decisions were left completely up to the states, districts, and schools on whether or not to adopt the NGSS and how to plan for implementation of the new standards. It is for these reasons that this project chooses to focus on these three levels (i.e., state, district, and school/teacher levels) when it comes to looking at how decisions about policies for implementation are considered.

Additionally, this study focuses on a limited context of policy, which has not been well addressed in studies of standards reforms or in large-scale implementation, known as local-control. Local-control states differ from centrally controlled states in one key aspect, which is that the curricular and programmatic decisions are generally made by local government, with much less influence from the state than in a central-controlled state. This includes the curriculum materials that are used in schools, the instructional practices employed in the classroom, and the

course syllabi, credits given, and time spent on each subject. These decisions are not just a matter of preference, but in many local control states, the state government is prohibited from influencing these decisions. In contrast, central-controlled states can generally mandate change and use of particular educational research as well as determine the curriculum and programs to be taught (Kingdon, & Thurber, 1984).

Of course, states do not simply fit into a local- versus central-control dichotomy; and there has been much research to show how states share a full spectrum of policymaking decisions (Kirst & Wirt, 2009). Walberg (1992) has shown that in states that lean more towards the local-control side of the spectrum, districts, school boards, school staff, and even citizens within the school district perceive a greater stake in the overall system. While the anonymity of the states in this study will be preserved, it is useful to discuss where on the local- versus central-control part of the spectrum they would be found. While there are many metrics one could use to determine where the locus of control lies within a state education system, Table 1 below identifies four metrics that illustrate how the two states in this study, states A and B, compare in terms of local- versus central-control with other states. The four metrics show whether or not a state currently has state-level science standards, state-level science assessments, is a textbook adoption state, and if there are implications for students passing the state-level science assessment. As seen in the table below, states such as Rhode Island along with the two focus states for the study, and to a lesser extent New York and Kansas, exhibit characteristics of local control in terms of textbook adoption and implications for assessment. Conversely, states such as Texas, California, and Florida are more central controlled in terms of not only standards and assessments and their implications, but also teaching materials used in classrooms.

Table 1:
Spectrum of State Education Systems: Local-Control to Central-Control

State	State Science Standards	State Science Assessment	Textbook Adoption	Implications for Assessment
Rohde Island	X	X		
State A	X	X		
State B	X	X		
New York	X	X		X
Kansas	X	X		X
Florida	X	X	X	X
Texas	X	X	X	X
California	X	X	X	X

Source: Snyder & Dillow (2012); Zinth (2005)

As Fuhrman & Elmore (1990) note, "[l]ocal actors are important participants in the discussions and decisions that shape the scope of the enterprise. Very often local initiative surfaces new conceptions of schooling and raises issues to the level of policy debate" (p. 93). Similarly, Strang (1987) documented how local control states have less bureaucracy and more autonomy from more central-controlled states, and, as one might expect, more actors are involved in setting educational policy in a local-control context. The opportunity to collect more data due to the additional actors involved in the decision-making process, and to examine how these decisions are disseminated throughout a larger and more complex system, is the primary reason why this study will concentrate narrowly on local-control states.

Salient to this research is the policy construct put forward by Spillane, Reiser and Reimer (2002). Their research focuses on how the sense-making of education policy initiatives by

"implementing agents'", especially initiatives related to standard-based reforms, influences the implementation process. This research also sketches a cognitive framework of implementation that identifies implementing agents' sense-making as it relates to policy implementation. Their focus is on the psychology of how implementing agents come to understand the policy issue itself, what the implementation process requires, and how they then disseminate this information to the people they are responsible for informing. They do this by focusing on three core elements; the individual implementing agent, the situation in which sense-making occurs, and the policy signals (Spillane, Reiser and Reimer, 2002, p. 392). This research around sense-making is important to this study because both the actions and the *reasons for the actions* by actors at three levels of the local-control system are considered with respect to how they influence the possible implementation of the NGSS.

Also important to this research is Elmore's (1980) constructs of forward and backward mapping. The basic premise of both forward and backward mapping is that they constitute, "two clearly distinguishable approaches to implementation analysis" (p. 602). Both forward and backward mapping assumes that policymakers are highly motivated to affect, "the implementation process and the outcomes of policy decisions" (p. 604). Forward mapping starts with a statement of intent from a policymaker. It then proceeds by identifying in as much detail as possible what is expected to happen at each level of implementation and ends with the outcome being measured by the original statement of intent. While forward mapping can be useful in analyzing implementation, it makes several assumptions that may hinder the conclusions one can draw from such an analysis. Most notable is the assumption that policymakers can, "control the organizational, political, and technological processes that affect implementation" (p. 603). In contrast, backward mapping begins with the last possible stage of the implementation process and aims to describe the specific behavior at this level that "generate[s] the need for a policy." Then the analysis proceeds by asking specific questions at each level that aim to identify the ability each level has to affect the identified behavior and the resources they need to make this happen. This study aims to further explicate the ways that these needs and motivations for policy

implementation specifically related to science standards are related across three levels of the selected local-control state systems.

Research Concept

The NGSS themselves – like most of the education research reports previously mentioned – are nothing more than words on paper, and although they outline the content, crosscutting themes, and scientific practices that all students should know, there are bound to be a variety of outcomes and policies that are designed to support these standards in the end. As noted in a recent report from the NRC,

> There is a clear inferential link between the nature of what is in the standards and the nature of classroom instruction. Instruction throughout K-12 education is likely to develop science proficiency if it provides students with opportunities for a range of scientific activities and scientific thinking, including, but not limited to: inquiry and investigation, collection and analysis of evidence, logical reasoning, and communication and application of information (NRC, 2010, p. 137).

The question becomes, if the "it" is the education system, then who is responsible for creating these "opportunities," and how, and by whom, is the "nature of what is in the standards" being supported? Further, in order to predict how state and local level policies can help support the implementation process of the NGSS it is helpful to understand how the educational system has reacted to many of the past efforts mentioned above.

The reason for focusing on the epistemology section is because I had anticipated that this would be the most difficult component of the NGSS for policymakers, state departments of education, and curriculum developers to deal with. Research has shown that reorganizing content using standards is not a significant hurdle, but integrating the practices into that content in order for students to come to understand science as a way of knowing is (NRC, 2011b). This difficulty with the integration may be for very practical reasons, such as the epistemology has been generally left out of science education (e.g., it is more difficult to assess, it requires more resources and is therefore too time consuming and expensive, it is not well understood by those

attempting to implement it, etc.), but it may also be because it is unclear to various policymakers throughout the system the relationship between students' understanding of epistemology and students' understating of content.

Reorganization of the content within already existing curriculum is not an effective way to align to the NGSS. One-way to ensure that this is not the case is to enact policies that support the integration of the practices, and require schools and teachers to use this integration of content and practice to build students' scientific epistemology. Even with these policies, it is possible that states could still see these standards as either too significant a change or too great a stress on their system to make any real effort. It is also possible that these same stakeholders might only see the changes that are needed as superficial and could decide that they do not warrant any action. The fact that the NGSS have been written allows for a unique opportunity to study policy around the implementation of epistemology, and how decisions are made by those empowered to set these policies. This is because the NGSS science practices provide the most complete vision of how a scientific epistemology should be integrated into the K-12 school curriculum. Also, given the scale of this effort, it has captured the attention of many education stakeholders and could certainly require policy changes at the state and school district level.

Research Questions

Considering that the focus of this research is on members at each of the three levels of the state education system in a local control state – 1) the state level, 2) the district level, and 3) the school/teacher level – this investigation answers the following questions:

1. To what extent, and in what ways, do members in each of the three levels of the state education system advocate for adoption and implementation of the Next Generation Science Standards?
2. Are the members in each of the three levels motivated or compelled to consider adoption and implementation of the Next Generation Science Standards, why or why not?
3. To what extent, and in what ways, do the members in each of the three levels take into account science epistemology in their overall consideration of adoption/implementation of

the NGSS?

These questions are critically important to the field of science education. As Dr. Ferrini-Mundy (2010) stated, “the trouble with research work in science education and math is that it doesn’t necessary get used or picked up by the policy makers” [sic] (p. 5). Her comments were part of the opening remarks during a conference that was put together by the National Science Foundation (NSF) and the University of Delaware to address the lack of policy research in the science education research community. Dr. Ferrini-Mundy went on to state, “something we also need to think about in setting a research agenda: What would make the work useful and usable – even if that research work already exits” (McEver, 2010, p. 5).

CHAPTER THREE:
Methodology

Methodological Synopsis

This study documented and analyzed the perceptions of members at each of the three levels – 1) the state level, 2) the district level, and 3) the school/teacher level – in two local-control states with regards to adoption and implementation of the NGSS. Specifically, this study examined why members at each of the three levels made decisions to either support or oppose the adoption and implementation process of the NGSS. The purpose of this study was not to describe the final outcome of the adoption process (i.e., if the state adopted the standards or not); rather, the purpose was to analyze how decisions were made, and what influenced those decisions, at each of the three levels. This research focused on describing how each member perceived his or her impact on the overall process, how they interpreted the decisions of others, and what influenced or motivated them in their decision making process. The primary audiences for this research are national, state, and local policy makers, curriculum developers, assessment developers, standards writers and the research community.

Data Sources

Prior Study

The data set for this dissertation research drew from interview data collected from the 2012, *Challenges of Implementing the Next Generation Science Standards in Local-Control States in the U.S.* study (Sevian, Foster, & Scheff, 2012). The Sevian, Foster, & Scheff (2012) study set out to examine how States' science education policies may impact the "five elements" of the NGSS identified by the authors. These five elements were:

1) Progressions of learning across grade spans

2) Integration of practice and content in standards

3) Inclusion of engineering with science

4) Incorporation of cross-cutting concepts, and

5) A career- and college-readiness perspective

The Sevian, Foster, & Scheff study focused on process in each of the five areas, and helped to identify who the decision makers are in the local control states that inform the discussion around adoption and implementation of the NGSS.

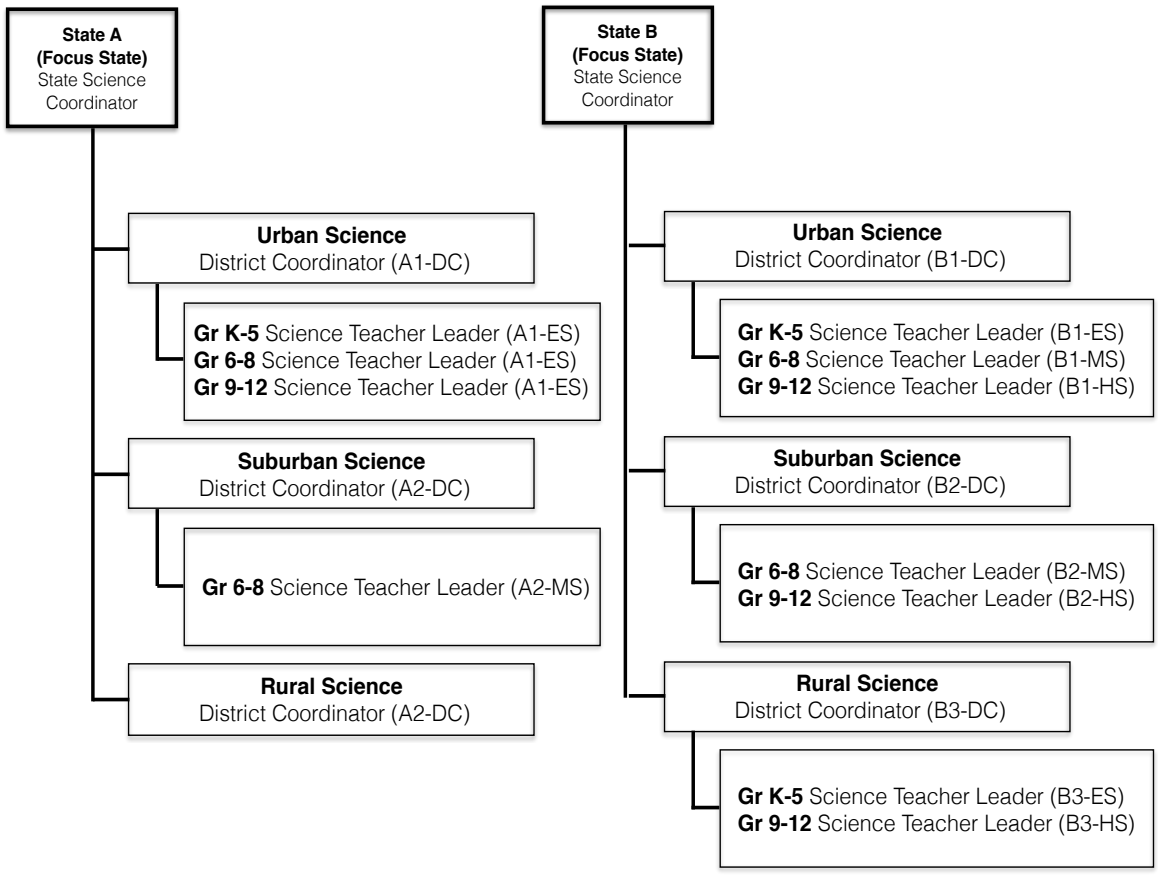
What separates this dissertation research from the Sevian, Foster, & Scheff (2012) study, is that this dissertation research is examining why and how decisions are made throughout the initial planning stage of the adoption and implementation process and investigating this process based on the epistemology as outlined in the NGSS. The Sevian, Foster, & Scheff (2012) study *did not* examine why, or what compelled, decision makers to act as they did, nor did it explore deeply the role science epistemology played in the decision making process, although the data that they collected did allow for such an investigation. In retrospect, after all of the data were collected and analyzed for the 2012 study, the Sevian, Foster, & Scheff team realized that the interview data contained much more detail and nuance that would allow for further investigation of their original research questions. The Sevian, Foster, & Scheff team was unable to devote the resources needed to study the data further, and in conversation with the team, I was invited to explore, post-hoc, the possibility of using these data for my dissertation research. Also, because of Dr. Foster's position within the Massachusetts' Department of Education as the Director of Science and Technology/Engineering and his involvement with the Chief State Science Supervisors (a national group of state science supervisors that meets regularly throughout the year), the Sevian, Foster, & Scheff team had unique access to appropriate state and district level stakeholders around the country. Additionally, Dr. Foster's position allowed the team the legitimacy to secure these interviews, which would have been more difficult for a researcher without his credentials. To date, the Sevian, Foster, & Scheff research has not been published and the project is currently on hold while the researchers await further funding and resources for this study. All of the work, including all of the data collection and the preliminary findings from the Sevian, Foster, & Scheff (2012) research, has, to date, received no external funding.

Setting

Each of the states in this data set is a local-control state. Each state is also considered

one of the *"lead states"* in the NGSS development process. During the NGSS development process, 26 states applied and were chosen to, "provide leadership to the writers and to other states as they consider adoption of the NGSS, and address common issues involved in adoption and implementation of the standards" (NGSS Website, 2012). Interview data collected for this study was gathered at the state level from six local-control state science coordinators. Selection was based on geographic diversity and a range of science achievement, as well as diversity of social, economic, cultural, and industrial bases. Additional data was then collected from two "focus states." Although the full data set includes a range of data from six states, this study only examined the two "focus" states where data were collected at all three levels of educational governance: state level, district level, and school/teacher level. For reasons of confidentiality, this analysis keeps the states, districts, schools and teachers that participated anonymous. The two focus states are referenced as State A and State B. The districts within each state are referenced according to their urbanicity (i.e., Urban, Suburban, or Rural). Finally, the school/teacher level is referenced according to the grade band they teach (i.e., K-5, 6-8, 9-12). Figure 1 below outlines all of the data collected for this study and how these data are organized at each of the three levels; state level, district level, and the school/teacher level.

Figure 1:
Organization of Data Collection



Participants

Notable characteristics of the participants within each focus state interviewed for this study are that they represent schools or districts with a wide variation of enrollment, socioeconomic status, high school graduation rates, and science achievement levels. Participants were specifically chosen to participate to ensure that the data would include this wide variation. Participants were recruited via email correspondence. The recruitment phase began in December 2012 and all participants were identified by February 2013. All of the recruitment of participants was handled by Dr. Hannah Sevian, Associate Professor, Department of Curriculum

and Instruction at The University of Massachusetts Boston. The original recruitment email that was sent to all participants from Dr. Sevian is included in Appendix B.

While these data include mostly female responses, the participants ranged in experience from 3 to 23 years in their current role. The participants include educational service administrators at the state and district levels, as well as school district science coordinators at the district level, and science teacher leaders at the school level. These district science coordinators were interviewed at urban, sub-urban, and rural districts, two in each respective category. From each district category this research aimed to interview teachers in three grade-bands (K-5, 6-8, and 9-12). Unfortunately, not all of the teachers were able to participate, and one of the teachers asked to be removed from the study. Table 2 below outlines each of the three levels of educational governance and the roles and typical responsibilities of the participants within each level that was interviewed, as well as the number of participants at each level.

Table 2:
Outline of Participants

Level of Educational Governance	**Participants and Typical Responsibilities**	**Number of participants**
State Department of Education	State Science Coordinators Person responsible for coordination of science standards, curriculum, licensure, professional development at the state level	N = 6 2 focus states; 4 non-focus states
School District (district types: urban, suburban, rural)	School District Science Directors Person(s) responsible for district science curriculum, instructional materials, budget, coordination of resources, evaluation of science teachers, professional development, and materials	N = 12 2 of each district type in each focus state

Grade Span	Science Teacher Leaders	N = 11
(K-5, 6-8, 9-12)	Person responsible for, or in a position to lead, peer leadership of grade band science staff, coaching or mentoring science teachers, disseminating information about science, and/or advising the district director on science curriculum and instruction	The goal was 1 at each grade span in each school district. In the end, several interviews fell through and one teacher asked to be removed from the study.

Source: Sevian, Foster, 2012

Instruments

Interview Data

All of the interviews were conducted in a semi-structured manner. Each interview contained a set of a priori interview questions as well as a set of secondary categories where the researchers decided they wanted to focus the interview. The a priori interview questions were divided into three primary categories. Each primary category contains questions that are specifically oriented towards each person interviewed depending on the level where they participated (i.e., the state level, the district level, or the school/teacher level). These primary categories are:

1. Motivation for implementation
2. Nature of policies around NGSS
3. Issues around suggestions for change

The secondary categories, five in all, helped focus the interview around topics that were predetermined to be important areas to collect additional data. These secondary categories did not contain any a priori questions but allowed the interviewer to structure follow-up questions around sub prompts to keep the interview focused. The secondary categories are:

1. Progressions of learning across grade spans
2. Integration of practice and content in standards

3. Inclusion of engineering with science
4. Incorporation of cross-cutting concepts
5. A career- and college-readiness perspective

It was decided before data collection commenced that state and local policy would focus on some of these areas more than others, and that it would be important to capture this in the interview. The complete data collection protocol can be found in Appendix B.

While the interviews were semi-structured, the primary categories did contain sets of questions that were asked during each interview. These questions provided opportunities for participants at each level to respond to the three research questions in this study. Specifically, these interview questions allowed participants to discuss the extent they advocated for the NGSS, what compelled or motivated them to consider adoption or implantation of the NGSS, and in what ways they took into account science epistemology in their overall consideration for adoption and implementation of the NGSS. Table 3 outlines the three research questions for this study and how these predetermined interview questions may support each of the research questions at the three different levels (i.e., state level, district level, and school/teacher level).

Table 3:
Interview Questions

Research Question	**Interview Question**
To what extent, and in what ways, do members in each of the three levels of the state education system advocate for adoption and implementation of the Next Generation Science Standards?	State Level - What are the traditional roles and responsibilities of the State in supporting implementation of new Standards? How will (might) that be different for implementing these new Standards? Why? What roles and responsibilities are traditionally left for districts to take on? How will (might) that be different in this implementation? Why? What sorts of resources will the State need to provide to support effective implementation of new Standards?

	District Level - What functions or roles does the district play in supporting the implementation of new Standards in your schools? How is your district, or will your district be, working differently with the State and with teachers than it has in the past on implementation (planning)? Besides policy, what resources will the district provide (or are preparing to provide) to support implementation of new Standards?
	School/Teacher Level - Why are you interested in the new Standards? Is there pressure on teachers to implement them? Where does that pressure originate and do you consider it to be positive or negative?
Are the members in each of the three levels motivated or compelled to consider adoption and implementation of the Next Generation Science Standards, why or why not?	State Level - What assumptions underlie your State's local-control policy context? How do they influence the State's approach to motivate and/or compel districts to implement new Standards?
	District Level - What motivates your district to implement new Standards? Why is it worth implementing new Standards in your district?
	School/Teacher Level - Why are you interested in the new Standards? What motivates you to implement them? Is there

	pressure on teachers to implement them? Where does that pressure originate and do you consider it to be positive or negative?
To what extent, and in what ways, do the members in each of the three levels take into account science epistemology in their overall consideration of adoption/implementation of the NGSS?	State Level - What are the most important policies your State has, is preparing to put into place, or could develop to help schools and districts implement the new Standards? Why are these policies so critical? What current policy(ies) do you anticipate changing to support district implementation?
	District Level - What district-wide policies or practices have you (or are you preparing to) set in place to support implementation of the new Standards? What functions or roles does the district play in supporting the implementation of new Standards in your schools? How is your district, or will your district be, working differently with the State and with teachers than it has in the past on implementation (planning)? What functions or resources should the State provide to the district (or schools or teachers) to support implementation?
	School/Teacher Level - What are your responsibilities in implementing new Standards at your school? In what ways does (or will) your district support your implementation of new Standards? Are their functions or resources your district or State should provide to teachers to support implementation of these new standards?

With respect to research question three; I recognize that none of the interview questions specifically ask about participants' understanding of, or views concerning, science epistemology. There are two reasons for not making this explicit in the interview questions. First, using the term science epistemology – or even the notion of how scientific knowledge is constructed – and asking participants in an interview setting to explain their action in terms of this epistemology was considered, by the Sevian, Foster, and Scheff team, to be overly intimidating. Second, given that the focus of the research question relates to the "extent" and "ways" that the participants "take into account" science epistemology when considering adoption and implementation of the NGSS, it was not as important to ask questions that specifically related to *participants' understanding* of science epistemology. Instead, it was more important to investigate their awareness of how the NGSS differ from other standards that they are familiar with due to the NGSS' focus on science epistemology. It was also important to investigate the level of appreciation each of the interviewees had regarding the emphasis that the NGSS placed on science epistemology.

For example, the following questions would allow an opportunity for a teacher to discuss ways that the NGSS specifically integrated science practices into the learning objectives that students would be responsible for, turning the sole focus of the standards from the content of science to include the learning and construction of knowledge in science.

- In what ways does (or will) your district support your implementation of new Standards?
- Are their functions or resources your district or State should provide to teachers to support implementation of these new standards?

Distinguishing this focus of the NGSS is critical as this research utilizes the term epistemology as a label that specifically relates to stakeholders' appreciation of how the science practices within the NGSS focus on the learning and construction of science knowledge, rather than explaining stakeholders' understanding of the theoretical underpinnings of science epistemology.

Furthermore, all of the interview questions associated with research question three are open-ended and required the participant to provide a detailed rationale for what influenced them

in making their decisions. The semi-structured nature of the interviews allowed for follow up questions to probe deeper into participants' responses if a rationale was not sufficient. The interviewers were told to specifically push on interviewees' perceptions on what was different in the NGSS from their current state standards. Thus these questions allowed for ample data collection around research question number three.

Data Collection

All of the interviews were conducted by graduate students at the University of Massachusetts Boston, under the supervision of Dr. Hannah Sevian, who also trained the graduate students on how to conduct the interviews. None of the graduate students had been involved in the writing or implantation of the NGSS prior to conducting the interview as it was decided that researchers who had worked on the NGSS, or were working on the NGSS implementation process, would bias the interviews. Each interview was audio recorded digitally by the graduate student conducting the interview of the participant. For the purpose of confidentiality, there is no personal identifying information associated with the recording, only the information that identifies the level of the person interviewed (e.g., state A, urban district, 9-12 science teacher lead). Graduate students at the University of Massachusetts Boston then transcribed each audio recording. Dr. Hannah Sevian checked all transcripts for accuracy and then all of the audio recordings were destroyed. The interviews were conducted over a 3-month period starting in February 2013 and ending in May of 2013. The data includes a total of 23 individuals that participated in interviews: 6 State science coordinators, 6 district-level science coordinators (three from each focus state), and 11 teachers (three from each district).

Data Analysis

Phenomenography

An expectation going into this study was that members from each of the groups interviewed would have a different perception of what the NGSS are trying to accomplish and the role that each group has in planning for the adoption and implementation process. In addition, each interviewee was likely to have different reasons that compelled or motivated him/her

decision-making as they considered whether they did or did not support the initial phase of adoption and implementation of the NGSS within their state. This study identified how these decisions were made, who the most influential players were, and what governed their decision making process. It is for these reasons that I employed a phenomenographic methodology as this allowed for the most appropriate investigation of the different ways in which the participants interviewed thought about, and came to make a decision about, the adoption and implementation of the NGSS (Marton, 1986).

Phenomenography is a methodology that seeks to identify the multiple conceptions, or meanings, a particular group holds and highlights their understanding of a particular phenomena. In educational research, phenomenography is focused on the conceptions of the group or individuals being studied, so the researchers' conception of the particular phenomena that is being studied has little bearing on the outcome of the research. The purpose of a phenomenographical study is that the researcher is to communicate the ideas, beliefs and reality of the participants being studied, and to remain as neutral in the process as possible (Miles & Huberman, 1994). As Marton (1994) describes it, the researcher is not studying his or her own awareness and reflection, but that of the subjects (p.4427).

Data analysis using phenomenography

This phenomenographical research study analyzed data in a two-step process. First, all of the interview data was coded using what Miles & Huberman (1994), call "provisional 'start list' codes." As they suggest, these initial codes come from elements of the research questions for this study, and, as typical in phenomenographical research analysis, I began with a minimal number of codes to start (Miles & Huberman, 1994). These codes also identify description categories for various conceptualizations of each level; 1) state, 2) district, 3) school/teacher. Every effort was made to explain all variations in the data using this initial coding scheme, which is outlined in Table 4 below.

Table 4:
Initial Coding Scheme

Initial Codes		
Advocating for change	Not advocating for change	Advocating against change
Reasons motivated for implementation	Reasons not motivated for implementation	Reasons motivated against implementation
Reference to an aspect of epistemology	Use of epistemology in argument	

The second step examined the initial coding of the data closely for fit and power (Miles & Huberman, 1994, p. 58). In this study, fit and power refer to the ability of the coding scheme to describe the different experiences members of each level within the state education system have in relation to each of the three research questions. As the data coding progressed, it became clear that these initial codes were not sufficient in terms of fit and power, and additional codes were needed. These emergent codes came in two types. First, while initially coding the data for the first time, patterns that were not explained by the initial codes were categorized. Second, patterns that emerged within the initial coding scheme were further refined to get at the deeper level patterns within the interviews.

During this iterative process of coding and recoding of the data it was important to keep focused not only on the particular aspects of the research questions, but also interesting patterns that emerged. These emerging patterns served as the bases for new emergent codes and this iterative process of reexamining the coding scheme and continuously redefining categories until the categories accurately represented the meaning continued until a “decreasing rate of change” was found, and “the whole system of meanings [was] stabilized” (Marton, 1986, p. 43). The purpose of finding the stable meaning is that this study is not attempting to simply restate what each interviewee indicated, rather, what each interviewee meant by responding the way they did in each interview (Marton, 1994, p. 4428). To accomplish this, this study had to consider not only

the categories of description, but also how each of the categories related to other individual or groups of categories, and how an individual member's conceptions compared across different topics. In the end, a well-defined and consistent coding scheme emerged.

Description of codes

This emergent coding scheme resulted in two forms, primary codes and secondary codes. Primary codes focus on the interview data that is proximal to the three research questions. These primary codes are tied holistically to the nature of the conversation that occurred between the interviewer and the interviewee, and, because they were directly derived from the research questions, the primary codes allowed for analysis of how the interviewees' responses related to each of the four research questions.

Secondary codes emerged as part of the iterative process of coding, and were assigned to each of the primary codes as needed. These secondary codes are more refined in detail and inform the emphasis that each interviewee placed on particular components of each of the primary codes. For example, research question number two is; "Are the members in each of the three levels motivated or compelled to consider adoption and implementation of the Next Generation Science Standards, why or why not?" A primary code that relates to research question two is "Challenges of implementation." Two of the finer secondary codes that allow for a deeper understanding of how the primary code relates back to research question number two are; "Chal: Developing appropriate resources" and "Chal: Required change to state policies." Table 5 below outlines all of the primary and secondary codes that were used and defines each code.

Table 5:
Primary and Secondary Code Descriptions

Code	Description
Challenges of implementation	*These set of codes are focused on the **challenging aspects** of the adoption/implementation process at a given level*
Chal: Collaboration	Challenges related to collaboration between the levels or within levels

Chal: Creating a coherent system	Challenges related to making the system coherent
Chal: Standards fatigue	The NGSS are too much of a change, place too much burden, or seen as detractor from motivation.
Chal: Differences between current and new standards	The NGSS are too different, and therefore misaligned, to current state standards.
Chal: Lack of stakeholder leadership for STEM	Not enough leadership to support the new standards
Chal: Obtaining buy in from field	Challenges related to others acceptance of the NGSS within the field of science education
Chal: Boundaries of local-control states	Challenges of implementing the NGSS in a local control state
Chal: Development of state assessment	Challenges related to state assessment(s)
Chal: Consolidating scattered resources	Challenges related to finding resources, or figuring out what resources are available and making them accessible
Chal: Teacher change	The ability of teachers to implement the NGSS, elementary school teachers' comfort with science content, a shift in teacher pedagogy, and teachers familiarity with content and practices
Chal: Developing and making available appropriate resources	Achieving consensus on what resources are needed, adopting resources, the usefulness of resources, and the influence of prior curriculum/assessment/professional development materials.
Chal: Adjusting state policies	Challenges related to changes that might be needed to state policies in order to adopt or implement the NGSS.
Chal: Value placed on science Ed	Education policy or schools/districts prioritizing ELA and math over science, public perception that science matters less than other subjects, this may include AYP or accountability in other subject areas
Factors effecting change	*These set of codes are focused on **why** things happen at each level and the sources of pressure or incentives for individuals or organizations to change. **Why** do they want to change, or **why** do they feel they have to change?*
Fact: Assessments	Positive or negative ways that assessment drives decision-making and action

Fact: Change as an opportunity or empowerment	Change as opportunity to engage field, to empower leadership or intellectual engagement of teachers, etc.
Fact: Funding linked to implementation	Implementation of new standards as a condition for awarding of funds
Fact: New or modified legislation	Legislation to change graduation requirements or the order or scope of science courses (e.g., teaching bio in 9th grade and chem in 10th grade, or adding an Earth Science course)
Fact: Professional development	Common interest for PD or recognition of the need for new or additional PD
Fact: Science literacy	Seen as an opportunity to achieve science literacy for all students.
Fact: Aligned with or supports current efforts	NGSS implementation aligns with the Common Core State Standards or other current science efforts
Fact: Licensure	Change in teacher licensure requirements (e.g., adding an engineering teaching certificate)
Fact: Availability of resources aligned to standards	When there is a need for the resources, people will go to what is aligned; the message will be delivered with them; resources could include sample curricula, PD, model units
Fact: Realization of common values, desires, hopes	Motivating around common values, such as shared goals, prep for business/industry, appreciation of rigor of the new standards
Policies	*These set of codes are focused **policies** that are currently in place or **policies** that would need to be considered to make the NGSS implementation successful*
Pol: Licensure	Teacher licensure policies
Pol: Legislative implications for curriculum decisions	Who makes decisions about curriculum, and how might this impact the NGSS?
Pol: Educator evaluation	Policies around teacher accountability measures
Pol: Assessment and accountability	Policies around student accountability measures; can present as "mandate" seen by teachers as coming from district or state
Implementation strategies	*This section is focused on **how** implementation of new standards is to be accomplished.*
Strat: Advocate for new/changed legislation	Advocating for new legislation

Strat: Consistent messaging across levels	Coherence and synergy across levels, raise awareness of vision of the new standards
Strat: Create aligned assessments	Creation of new assessments aligned to the NGSS
Strat: Engage resources for change from outside organizations	Cooperate and coordinate with other organizations, e.g., professional societies
Strat: Foster collaboration across districts	Collaboration between districts
Strat: Learn from Common Core rollout	Lessons learned from the Common Core State Standards implementation process so that it can be built upon with NGSS rollout
Strat: Learn from successful districts and schools	Sharing what works from one school or district to another
Strat: Learn what stakeholders' issues are so an agenda can be developed	Stakeholders include, for example, principals, superintendents, boards of education, PTA, teachers unions
Strat: Provide PD to support implementation	New or additional PD to support implementation
Strat: Strategically use available funding	Federal or State DoE funds such as grants to do specific aspects of NGSS implementation support
Strat: Create/organize resources	State and districts providing new curriculum resources (e.g., textbooks or curriculum)
Advocate	*Has the interviewee advocated for or against the NGSS?*
Adv: Advocating for	Advocating for the NGSS or aspects of the standards that are different from the current state standards
Adv: Not advocating for	Not advocating for the NGSS or aspects of the standards that are different from the current state standards
Adv: Advocating against	Advocating against the NGSS or aspects of the standards that are different from the current state standards

Motivation	*Aspects of the standards or the interviewees personal perspective that motivates them to consider implementing the NGSS*
Motiv: Reasons motivated for	Stated reasons motivated for implementation
Motiv: Reasons not motivated for	Stated reasons not motivated for implementation
Motiv: Reasons motivated against	Stated reasons motivated against implementation
Epistemology	*The extent to which an awareness of how science knowledge is constructed influences their consideration of the NGSS*
Epist: Referenced epistemology	References science epistemology in the NGSS
Epist: Used science epistemology	Uses specific aspects of the science practices of the NGSS as a reason for liking/disliking the NGSS
Components of the NGSS	*Comments on the elements of the NGSS that come from NRC Framework or one of the NGSS drafts of the standards*
NGSS: Career- & college-readiness	Interviewee references aspects related to college- and career-readiness
NGSS: Crosscutting concepts	Interviewee references aspects related to inclusion of crosscutting concepts
NGSS: Engineering	Interviewee references aspects related to inclusion of engineering with science
NGSS: Progressions	Interviewee references aspects related to progressions of learning across grade spans
NGSS: Practice-content	Interviewee references aspects related to integration of practice and content in standards
Possible Misconceptions of the NGSS	*Apparent misconceptions about what the NGSS are, or how they are intended to effect science education at the state, district, or school/teacher level.*
Informative quotes	*Good quotes that I wanted call out from the interviews.*

All of the quotes that are discussed in the findings and discussion sections in chapters four and five are tied to these codes. When discussing specific codes in these chapters, the

codes are italicized and cited. These citations reference appendix C. Appendix C, similar to Table 4, contains a description of each code, its definition, and also includes the addition of an example. After establishing the primary codes from the matrix above, each of the primary codes were assigned to one of the three research questions. Research question number one focused on advocacy at each of the three levels. The following primary codes were used in the overall analysis of research question number one:

1. Advocate
2. Implementation strategies
3. Policies

Research question number two focused on *motivation* at each of the three levels. For research question two, the following primary codes were used in the overall analysis:

1. Motivation
2. Factors effecting change
3. Challenges of implementation

Research question number three focused on *epistemology* at each of the three levels. For research question number three, the following primary codes were used in the overall analysis:

1. Epistemology
2. Components of NGSS

In addition, there were two primary codes that were not assigned to one research question, but instead informed the overall analysis more globally. These codes included,

1. Possible misconceptions of the NGSS
2. Informative quotes

After all of the interview data were coded and these codes assigned to research questions, the data were then analyzed for patterns that emerged both horizontally across each level (i.e., state, district and school/teacher level) and vertically within and between the two states. This multi-dimensional analysis of the codes allowed for what Tufte (1986) describes as a “clear portal of complexity.” The organization of the codes around the three research questions allowed

for conclusions to be drawn based on the patterns, themes, comparisons, clusters, and frequencies that emerged. Tufte (1986) describes this process as a way to access the subtle and difficult nature of the data and allows the complexity to be revealed that is hiding within the interviews (p. 80). The complexities of the data that have emerged from the patterns observed in this coding scheme were described to address the three research questions.

Tools

To code and analyze these data I used the online tool Dedoose. All of the transcript data is stored on the Dedoose platform, and the Dedoose tool allowed for a robust coding scheme to be created for this study. The Dedoose tool allowed for the data to be "chunked" so that codes could be attached to separate words, phrases, lines, or paragraphs. Additionally, these chunks were nested and relationships were graphically depicted to allow for a deeper analysis than "hand coding."

Reliability

The challenge for this study is in creating a consistent coding scheme that remained reasonably stable between different researchers, known as inter-rater reliability. To test for inter-rater reliability, two other researchers coded several sections of data. The researchers did not know how the codes were attributed to the data and the agreement between raters (the percentage of cases in which we agreed) was measured. Table 6 below shows the Cohen's Kappa value for each rater and then reports the mean average as the final measure for inter-rater reliability. Cohen's Kappa is a standard measure for inter-rater reliability (Cohen, 1960; Carletta, 1996) as it takes into account both the observed agreement (percentage of cases that the other rater agreed with the initial coding) as well as the expected agreement (the proportion of times the other rater would agree if they guessed on every case). A Cohen's Kappa greater than 0.7 is generally acceptable for this type of research, and the mean average of the Cohen's Kappa between the two raters was found to be 0.75 for this research.

Table 6:
Inter-rater reliability

Rater	Cohen's Kappa
Rater 1	0.70
Rater 2	0.80
Mean Average of the Cohen's Kappa	0.75

CHAPTER FOUR:
Findings

The findings for this research are guided by the research questions and are split into two sections within this chapter. The first section addresses the three research questions at each of the three levels of educational governance – the state, the district, and the school/teacher level – separately across the two focus states. In the first section, organizing the findings in this way made it is possible to examine how participants at each of the three levels uniquely focused on advocacy, motivation, and epistemology. The second section takes a more holistic view by identifying the key findings and comparing the similarities and differences across the three levels. In the second section, organizing the findings in this way helped to identify the most significant findings from the research and allowed for common themes to emerge across the interviews. These themes highlighted areas where participants at each of the three levels had common understandings and where differences existed in the ways that they were viewing and interacting with the NGSS.

Research Questions

All of the findings in this chapter are organized around the following three research questions and how these three research questions play out at each level in the local control state – the state level, the district level, and the school/teacher level:

1. To what extent, and in what ways, do members in each of the three levels of the state education system advocate for adoption and implementation of the Next Generation Science Standards?
2. Are the members in each of the three levels motivated or compelled to consider adoption and implementation of the Next Generation Science Standards, why or why not?
3. To what extent, and in what ways, do the members in each of the three levels take into account science epistemology in their overall consideration of adoption/implementation of the NGSS?

Throughout chapters four & five quotes from the interview data are provided to support

and highlight the analysis of the research questions above and the discussion of the findings. In some instances, quotes contain additional text, other than what directly relates to a specific code, in order to provide essential context for that code being analyzed or discussed. In most of these occurrences, it is obvious how the quote relates back to the code that is being examined. Where it is less clear, or when a quote is longer than several lines, the coded text is underlined to call out the specific part of the quote that relates back to the code being discussed.

The State Level: State Science Coordinators

Advocacy

The two State Science Coordinators (SSCs) in this study were generally positive about the NGSS, were well informed about the components of the NGSS and how they were constructed, but were only moderately interested in advocating for adoption. Most of their efforts to advocate for adoption did not center on *adjusting state policies* (Appendix C, row 13), but rather, they were much more focused on highlighting programs and synergistic activities that were already happening in their state, which they believed were related to the NGSS. The interview data suggest some of their modest advocating for the NGSS was associated with their frustration with their limited ability to influence the overall outcome of how the NGSS might be implemented in their state. This is likely a consequence of local-control state politics; while the SSCs can recommend policy changes, they are limited in how far their recommendations are taken, as local districts may not be required to adopt or employ them. Both SSCs stated explicitly their restricted ability to effect change within the education system, especially when it came to adopting or implementing policy, and their frustration in having such little power. For example, the SSC in state A noted,

> If an ISD[1], or a [State-Sponsored Center for Math and Science], or a consortium decides to write units, and then they take those units, and say, “Okay, everybody in our region, this is what’s required in our region.” Well, they can require

[1] ISD – Independent School District

> something in their region – I mean they can't really – but they can say they are, and districts don't necessarily have to follow it, but they can say, "We're only going to support professional development around these models," and unless somebody else calls them on it, and that's exactly what happens, and so we can't, as a state department, we don't have a whole lot of control in disallowing that message. (A-SSC)

The SSCs were more concerned about what they did have control over. This same SSC stated, "most educational decisions about curriculum, about teacher development, about program design for schools, or about graduation requirements, are determined by local districts, and the state has little authority or control over much of that."

Despite the SSCs feeling restricted in their ability to advocate for the NGSS, they still found ways to link the NGSS with initiatives that were very important at the state level in order to bring more attention to the standards. This is possible because the SSCs have direct access to the Governor and many of the state politicians with influence over how policies are realized at the district and local level. This also gives the SSCs the ability to choose where and how much to advocate for initiatives they want to support or that they want to avoid. For example, in state B, the SSC felt that he did not need to do too much advocating for the NGSS because the Governor already had STEM education as a part of his agenda. The SSC in state B stated, "I do think there's a lot of politics in our state around STEM education, and so we have a Governor, who, when he came into office promised all these reforms, and to put more money into STEM education." This SSC felt that it was best to let the NGSS adoption process take its course and not be out front advocating hard for the initiative because he/she felt that, given the Governor's support, it was going to be adopted. Instead, he/she felt that it was important to show how the NGSS were aligned with the Governor's goals around STEM education. This macro level perspective is specific only to the SSCs, and is presumably unique to the state level.

Other strategies for implementation that the SSCs felt were important in advocating for the NGSS included *consistent messaging across levels* (Appendix C, row 33). As the quote

below from the SSC in state A reflects, the SSCs felt that a primary role they should play is in raising awareness for the vision of the NGSS, and how these standards are different from other science education reform efforts.

> We've always done a big push to raise awareness and help people understand what the standards are, so that kind of awareness outreach, we've always have that kind of thing. But it's rarely gone beyond that. Well I shouldn't say that. We have traditionally supported some professional development around the new standards as well for several years after the standards are adopted, and we'll do that again this time. (A-SSC)

Both SSCs felt that consistent messaging was essential to the success of the NGSS in their state, and that this was something that should be organized at the state level.

Other strategies that the SSCs felt should be organized at the state level include the need to *create aligned assessments* (Appendix C, row 34) and *create/organize resources* (Appendix C, row 42), such as providing new textbooks and aligned curriculum. The SSC in state A explained his/her position as follows:

> We want to try to identify and make accessible a wide variety of resources. The Department of Education is not going to have much money to develop many resources, there is not a separate Race to the Top kind of effort underway, or other fund source available, and the state itself doesn't have all that much set aside for science education that I have control over. But we do have a wide variety of resources scattered across the state. And by resources I mean organizations that do science education, tools and curricula that's been developed by various districts or organizations, like museums and nonprofits and [Type of Industry] companies. And we have things like teacher and student internships at companies, or field trip opportunities, or family learning experiences, just all those kind of things. We have a wide variety of those. Our state is rich in that kind of stuff. But making those accessible, checking whether

or not those are actually supporting the new standards, and making them so that districts can make purposeful use of them, that's very challenging, because right now all of those resources are dispersed, and individually they're trying to outreach to schools, but we want to think about how to make that more centrally accessible. (A-SSC)

Motivation

Both SSCs were highly motivated to consider adoption of the NGSS, and neither SSC said anything negative about their motivation to adopt the standards. The interview data show that what motivates the SSCs the most in considering adoption and implementation of the NGSS is *assessment* (Appendix C, row 16). They felt that new assessments would be the primary factor affecting change and would be the reason the district leaders and teachers would be most compelled to pay attention to the NGSS. The SSCs also felt that they would have influence over what new aligned assessment would look like, at least state level assessments that districts and teachers would need to adhere to, and they felt that assessments would be the biggest motivating factor across all levels of the education system. The SSC in state A identified that, "the only way we can compel districts in [State] is through the state assessment, and through our school and district accountability system. Every school and district has to administer the state assessment." Having control over the state assessment makes the SSCs feel that they have the ability to put some boundaries on decisions that were made at the district and school level. They were acutely aware that while they did not have the authority to effect what was happening on a day-to-day basis in the schools, the state assessment allowed them to have some influence and in a way, "kept them in the game."

Indicators of Epistemology

As was noted earlier, both SSCs are well informed about the various components of the NGSS, but they did not clearly articulate how notions of science epistemology differed from the core content knowledge in the standards. At a high level the SSCs were aware that the science practices in the NGSS place a new emphasis on the knowledge and skills that a student is

expected to learn in science, but when pressed further on what this might look like the SSCs did not provide any specifics. In one instance, the interviewer asked the SSC from state B to, "elaborate on what [they] think is the most critical new pieces [of the NGSS]." The SSC started out by talking about content misalignments between the NGSS and the state standards, but eventually mentioned that many of their state's current science courses do not include an emphasis on the science practices. They did not provide any specifics, but did express the need to address the practices when planning for NGSS implementation. Specifically, the SSC in state B said, "it's most important for us to help people understand that there's a timeline, that there's a reason for taking our time, but that there's also a good reason to invest early in really getting to know these standards, and trying to begin implementing at least the practices within your current instructional model."

The SSCs also note how assessments will need to change in relation to the NGSS's focus on science practices. Again, their understanding of what these changes mean – at least in terms of reflecting students' understanding of science epistemology – appears to be incomplete, but they do call the practices out specifically. The SSC in state A notes, "[o]ur current assessment strategies have to do mostly with multiple-choice and some written response kind of things, but given the focus on practices in the new standards, we really want to make sure there is some performance assessment pieces in our assessment system." It is clear that both of the SSCs are aware of the emphasis science epistemology plays in the NGSS, but they do not volunteer any specifics other than mentioning the science practices section of the document. Given their broad statements about the practices, it is difficult to determine their level of appreciation for the emphasis placed on science epistemology in the NGSS.

The District Level: District Coordinators in Urban, Suburban, and Rural School Districts

Advocacy

All six of the District Coordinators were consistent in that they all strongly advocated for the NGSS. All of the District Coordinators had positive ways that they were advocating for the NGSS, and many of the ways in which they were advocating were organized, well thought out,

and consistent among the District Coordinators that were interviewed. The most important reason that the District Coordinators gave for why they were so strongly advocating for the NGSS was that they believed that the NGSS focused on *career- and college-readiness* (Appendix C, row 55). The District Coordinators felt that this focus on *career- and college-readiness* (Appendix C, row 55) in science was a shift from the current standards and curriculum in place within their states, and allowed for a more effective way to organize and teach a science curriculum. One District Coordinator stated, "I truly do believe that teaching science in a way that the Next Generation Science Standards outlines is a more effective way of teaching science so that kids understand and are able to remember and retain information for the rest of their lives" (B1-DC). Another District Coordinator stated, "…our goal is to have our kids college- and career-ready. And we know that the Next Generation Science Standards, from what we've researched on it, should align with college- and career-readiness standards" (B3-DC).

There were also several approaches that related to advocacy, which the District Coordinators cited as important to a successful implementation strategy. The first was *providing professional development to support implementation* (Appendix C, row 40) for teachers and school level administrators, which was the most cited strategy across all of the District Coordinators interviewed. Most of the comments around *providing professional development to support implementation* (Appendix C, row 40) were in conjunction with the need to *create/organize resources* (Appendix C, row 42) for them. For example,

> That doesn't mean anything unless you do a rollout plan where you support teachers in understanding the standards; you provide exemplars or modules of how to implement the standards; you provide materials or access to materials and equipment to do what's being required in the standards. It's going to have to be a comprehensive rollout plan that includes everything from just general information, so things like memorandums and that kind of thing, all the way down to professional development sessions where we go over the standards with the principals, the administrators, then the teachers. Then we talk about things

like…I mean, in the Next Generation Science Standards you have things like making models, writing scientific explanations. Well, there has to be quite a bit of professional development with teachers around those practices. When you talk about policies and practices you have to provide support around those. So, I would anticipate, obviously, we'd have face-to-face professional development, but I'd also anticipate that we're going to have to have some archived webinars or other resources. Ideally, I would love to have exemplars from teachers' classrooms who are actually implementing standards based, you know NGSS standards based practices and…so people have a frame of reference. And giving people ways to scaffold instruction around making models; around writing scientific explanations. I mean if we do not support teachers in understanding of being proficient themselves in these things, then most certainly our kids will not be proficient and producing in those practices either.(B1-DC)

The second strategy for implementation that the District Coordinators cited was to *engage resources for change from outside organizations* (Appendix C, row 35). This included utilizing published resources such as NSF materials or working on in-person collaborations. "I believe we will be looking for partnerships with universities, with non-profits, with businesses to help make the standards real. And so it may mean things like internships or visits or…just different kinds of collaborations that all would be coordinated through the district" (B1-DC). This focus on looking to engage outside resources demonstrates the emphasis on a 'systems approach' that the District Coordinators are taking towards implementation.

The third most often cited strategy for implementation by the District Coordinators was to *strategically use available funding* (Appendix C, row 41). District Coordinators cited the need for adequate budgets in order to provide resources and professional development for teachers. Various ideas as to how to obtain these funds were made including the possibility of

using Title I funds[2], or grants. The District Coordinators felt that including a plan for funding would be an effective way to advocate for their implementation. As one District Coordinator stated,

> First of all, there needs to be a new source of funding because we do have to change. We do have to change all of our textbooks. We do have to change all of the resources that we have for the kids. … And so we do need to change all of our curriculum. (A3-DC)

Another approach that focused on advocacy that the District Coordinators cited related to policies around *educator evaluation* (Appendix C, row 29). Their concern here was that the NGSS and the state student assessments must closely align to ensure fairness in the teacher evaluation process. If the tests are not closely aligned to the new standards, then it would not be fair to evaluate teachers on how their students are performing. One District Coordinator in a rural district noted,

> We now have teacher evaluations that need to be done annually for every teacher. So that policy which has just been changed within the last year in our state has definitely upped the stakes for all teachers. Fifty percent of their evaluation is now based on student achievement growth, so obviously that plays into it. You know, in terms of, we want to be teaching kids what they're going to be tested on because it basically affects teachers which in turns affects administrators all the way up to the top. So, that's now how we're evaluated. (B3-DC)

Motivation

Similar to the SSCs, District Coordinators named *assessments* (Appendix C, row 16) as the primary factor effecting change. As the SSCs predicted, state level assessments were a

[2] Title I funds are part of the Elementary and Secondary Education Act (ESEA) and provide financial assistance to local educational agencies and schools with high numbers or high percentages of children from low-income families to help ensure that all children meet challenging state academic standards (U.S. Department of Education, 2014).

major motivating factor for the district level, and was something that four out of the six District Coordinators cited as the most important part of the implementation process. As one District Coordinator put it,

> As representatives of the district if the state adopts the next gen, which they are expected to do right away, then it would be the obligation of the district to also adopt those standards because that is going to be the basis of future assessment and that will be the way that our students are judged proficient or not proficient. (B2-DC)

While the District Coordinators were obviously concerned with the state assessments, they also wanted assessments that were testing more than just students' knowledge. Three out of the six District Coordinators stated that they wanted assessments that gave them the ability to evaluate teachers in their district. This is not because they felt they needed to police teachers, rather they were looking for ways to measure successful programs and curricula. As one District Coordinator noted, "[t]hey're also going to start tying teacher evaluations to these test scores. So teachers are extremely concerned and students not so much. An interesting situation" (B2-DC).

Although the District Coordinators were only focused on one factor effecting change, they had much more to say on the challenges of implementation. Specifically, the District Coordinators focused in on three main challenges of implementation; *the development and making available appropriate resources* (Appendix C, row 12)*, teacher change* (Appendix C, row 11)*,* and *adjusting state policies* (Appendix C, row 13).

First, District coordinators cited *developing and making available appropriate resources* (Appendix C, row 12) as a challenge to implementation of the NGSS. While there was some mention of a need for published resources that support the standards, time and money received the most attention by far. District Coordinators cited professional development for teachers as the main reason for needing more time and money. The DCs felt that with appropriate resources, they would want teachers to create or adapt curriculum and assessments, which support the NGSS. One district coordinator from state A stated, "…a big need is going to be professional

development time because teachers are going to need to work on this to get things modified, and that costs money" (A2-DC).

Second, District Coordinators stated that the reasons for why they felt *developing and making available appropriate resources* (Appendix C, row 12) was a significant challenge to implementation was because with more time and money they could provide professional development which would support *teacher change* (Appendix C, row 11). District Coordinators felt that to implement the NGSS with fidelity, teachers would need to change their current instructional practices. Another district coordinator from state B stated,

> I suppose, obviously, professional development and training for the teachers. Like I said, what we've seen from the common core anyway, it's going to be a lot different in terms of teaching just the kind of expectations they have for the students. The depth of the concepts that they expect them to obtain. It won't simply just be teacher in front of student. There's a lot more in terms of technology added in there; collaboration; research; all types of different things that need to be implemented. And our teachers have to get comfortable with that. They talk about the amount of training that it takes to get teachers fully ready to teach that style. It's somewhere around 100 hours of professional development. It seems pretty unrealistic in terms of…I don't know (a) where do you find that time, and (b) how you pay for it. (B3-DC)

The last challenge the District Coordinators cited was the need for *adjusting state policies* (Appendix C, row 13). District coordinators cited issues primarily related to teacher licensure and how science courses would be structured in order to meet the NGSS. One district coordinator stated,

> Teacher certification would be impacted. So, what does that look like? Who's qualified to teach these courses? Are teachers gonna need to have… engineering cross training or an engineering education endorsement? You know, there's these kinds of things. So, I would say policies around teacher certification.

Policies around graduation. Those things definitely could create issues. (B1-DC)

Indicators of Epistemology

Based on District Coordinator responses around the practices section of the NRC Framework and the NGSS, it was clear that district coordinators have a more complete appreciation for how the NGSS incorporate science epistemology, and how this emphasis on epistemology is significantly different from science standards documents that they might be familiar with, when compared to the other two levels (i.e., state level and school/teacher level). Out of the six District Coordinators interviewed, they specifically *referenced epistemology* (Appendix C, row 52) or *used science epistemology* (Appendix C, row 53) in their interviews a total of six times. Also, the detail they chose to include when discussing the epistemological components of the NGSS, such as the practices section of the NGSS, was far greater than the detail provided by the SSCs or the teachers that were interviewed. The District Coordinators more clearly articulated how the practices focus students on how scientific knowledge is constructed, they were able to discuss in depth how the NGSS differ from other standards documents when it comes to the emphasis they place on epistemology, and they seem to understand that in order for students to achieve comprehension of the NGSS there is a need for a change in instruction. One District Coordinator stated,

> What I also want to say, it's not practices without content. Content and concepts are critically important, because you can't…it's just like the last time when inquiry was exciting. Inquiry into nothing is nothing. So, using science practices to really deepen understanding around content and concepts is really what I hope this is all about. (A1-DC)

This same District Coordinator went on to state that it was not just about changing instruction in the classroom, but this shift towards science practices would require new classroom resources as well.

> I've read these standards and there are different things in there. And if you've not been teaching those things, because they are very different, and it requires

science practices and engineering practices. Kids are going to have to have something in their hands. And so, there's going to be a need for some retooling of what we actually put in the hands of children. (A1-DC)

When another District Coordinator was asked to comment about state policies supporting or opposing implementation of the new standards, they responded by bringing up the role of the science practices in the NGSS and how this will significantly change the focus of the current science curriculum, which they note is "very content heavy."

….it's an entirely different I guess you could say philosophy in teaching, a different kind of style in teaching. Teachers are going to have to teach a different way…To find that depth. Looking at the concepts that they're going to be covering now and looking at the style, the way our kids learn too. We're throwing a lot at teachers now. We're throwing technology at them and we're throwing all these different things. I guess the biggest challenge is keeping them up to date. Getting them trained the right way. Certainly we've got a lot of tools though. The question becomes how do we use them and how do we get teachers to teach a little bit different, because that's what it's going to take. (B3-DC)

The School Level: Elementary, Middle and High School Teachers in Urban, Suburban, and Rural School Districts

Advocating for Change

The findings from the teacher interview data show a bimodal distribution. On one side of this spectrum, two teachers reported that they had participated in the open review process of the NGSS in their states while the standards were under development. The comments these two teachers made differed from their colleagues on the other end of the spectrum in that they were able to articulate how the NGSS would impact their classrooms and how the NGSS contained concepts of science epistemology.

And if you're really working hard in this science standards stuff you're going to have really, really well educated citizens. [laughing] You know, they're really

> going to be good advocates for themselves and for the environment. So I think that sort of putting it out there as sort of being a sort of a framework for looking at the way that you're thinking about educating students… They're fundamentally quite different, and I think that that's got to be the way that people get hooked into this notion of the Next Generation Science Standards. (A1-MS)

As a point of comparison, one comment from a rural high school teacher from state B shows this disparity clearly. "And again, I haven't really–I haven't seen the exact specifics of the Next Generation Science Standards. I don't know–is that the same things as common core" (B3-HS)?

All of the teachers choose to discuss the standards in a hypothetical way, which was a result of both states, A and B, not having committed to adopting the standards at the time the interviews were conducted. The teachers instead choose to comment on how to get teachers on board after the standards were adopted in general, not about how they themselves were planning to advocate for the adoption and implementation process. This is not to say that the teachers were advocating against adoption, but they seemed to be unaware that they had the option to participate in the discussion about whether or not the state should adopt the NGSS. Even the two well informed teachers expressed in their comments how they felt removed from having much agency regarding influencing adoption. They were able to provide feedback on the content of the standards, but they did not feel that they would be asked to participate in the ultimate decision about whether or not to adopt the NGSS.

Despite this, the teachers did have opinions on how the new standards should be implemented in the classroom and were concerned about repercussions of an adoption decision by their state. Four out of the eleven teachers conveyed that, like most state level processes, there was an expectation of things going one way, "from the top-down." These teachers did not expect to have much of a voice in the decision making process. However, these same teachers acknowledged that implementation was likely to be very bottom-up, so once the standards were adopted they had the ability to influence how they would be implemented.

Teachers cited *provid[ing] professional development to support implementation*

(Appendix C, row 40) as the most important way to advocate for the new standards. Teachers felt that providing professional development would support the NGSS and it would allow teachers to better understand how the new standards are different and how curriculum will need to change. It would also allow them to better understand how they will need to change their classroom teaching practices, and would identify what they – and their students – will be held accountable for. The common theme that emerged from the teachers was that with the "right" type of professional development for both teachers and building administrators, the NGSS would be less of a burden and could even be seen as a positive step in supporting high quality science education. It should be noted that three of the teachers felt that professional development should be geared not just for those teaching, but also the administrators that are responsible for curricular and policy decisions at their school. One of the middle school teachers in an urban district from state A commented,

> I think that there's a ton of PD about it. Because otherwise people are just going to freak out. (laughing) You know, they really are…they're very, very dense. And there's a lot of moving parts. And I feel like it could really be something that feels like it's scary and overwhelming. And how can you do one more thing? And in fact, if you're given…if teachers are given an opportunity to really understand how this whole thing works together, they can really…I think that with enough…enough of the right sort of PD, it could really be seen as a strength rather than as another burden.

Another theme that emerged from the interviews is the need for *consistent messaging across levels* (Appendix C, row 33). This appeared to be more of a concern with the teachers from state A as every one of the teachers from state A commented on consistent messaging as an important implementation strategy. Despite this, the teachers from state A did not identify a specific problem with communication coming from their state or district, but instead felt that a consistent message was an important way to advocate for the new standards. One high school teacher stated,

I mean, yea, I think once the state makes a decision about what to do, there should be some publicity of that. Even just to the general population about what's happening with science. Like it should be news about new science standards and the goals and preparing students to both - just people in general I think, and to target families and people who have children in school. Because I don't think our parents know a lot about what our kids are necessarily learning about science in our schools. And I think, that also at the district level should happen as well. (A1-HS)

Motivation

The most common reasons cited for motivation were a desire for the *realization of common values, desires, hopes* (Appendix C, row 25), including students' deeper understanding and value of science, and its application in the real world and a responsibility to follow mandatory policy if their state were to adopt the NGSS. There was also ambivalence towards implementation, which is evident primarily in concerned comments regarding teacher evaluation being linked to standardized student assessments. The only reasons given against implementation were in hypothetical scenarios of unfair teacher evaluations based on student assessments.

Out of the 12 total teachers that were interviewed, 8 teachers made specific positive comments regarding motivation for implementation. The idea that the NGSS would make their students more competitive in *career- and college- readiness* (Appendix C, row 55) was the most cited reason for teachers' motivation.

I want my kids to be ready. I want them to be competitive. And the new standards, the Next Generation Science Standards is very important for us to move towards this. We're linking from grade level to grade level and infusing inquiry standards, and really preparing them for a life and society that needs engineers and scientists who can think, can really think and problem solve. And I want my kids to be ready for that. I need to be ready for that because of course, I'm

> accountable for what certainly will be changing tests as well. I just want to be on top of…I consider myself very good at what I do, and I want to stay very good at what I do. (B1-HS)

Another teacher stated,

> I think we're heading into this culture, you know, with like technology growing really rapidly. And I'm sure 10 years from now it will be very different. And we just need to prepare the students for their future careers. And I think…in engineering…everybody's talking about technology, engineering, science. You know, as a country I think we are behind compared to other countries in the world, and…if we don't catch up soon we will be even more behind. So… I think it's just valuing these areas…and, not only the whole society…I think that the district, the schools, and I think for some people it's very hard to see that because we may be, in the past many years we have been seeing so much time and focus on literacy and math because people look at those scores, but…so hopefully science will be seen as a more important subject area.

Of the teachers that were more ambivalent in their motivation towards adoption, the common theme that emerged from the interview data was that the teachers felt they had to follow what was handed down to them. They felt that it was their job to implement the standards, whatever standards they might be, to the best of their ability but it was not their job to decide what the standards should look like; that was someone else's job. One elementary school teacher stated,

> The pressure that I feel from Next Gen I don't feel that it's positive nor negative. It is what it is. It's part of my job. It's part of my job. It's something that I have to do. So I don't…I mean, I'm not sitting here jumping up and down going 'Oh yeah! I've got, you know, another set of rules to follow!' It's just like, 'Okay, I've got another set of rules to follow.' And once I know what the rules are then I can proceed and do what's best for my kids to make sure that they meet the standards. (B1-ES)

Another teacher stated,

> Well, I obviously want to do what my employer and what the state government wants me to do as far as what they feel is best for me to teach in my courses, but I also–I think for me, what motivates me the most is to try to get my kids to understand main ideas, the bigger picture, and how things are related to one another…But I'm, I guess I'm the kind of teacher, I guess, that I do what I'm told to do and I try to make the best of it, if it's good or bad (B3-HS).

A small nuance to this ambivalence from some teachers included the additional pressure of accountability, both student accountability and teacher accountability. A middle school teacher stated,

> If I'm not required, I wouldn't do it because our… So if the state didn't adopt them and our tests were still geared towards the frameworks, I would teach what I would be responsible for or what the kids would be responsible for. Do you see what I'm saying? I wouldn't stray from what I'm told to teach…It's a terrible thing. And I hate that we're responsible and that people judge us based on those tests. But that's the reality of it is that, you know, if we get a test score back and we are low in a certain area, they'll say did you teach this. And it's very difficult for us in our district because we don't have technology teachers. So in addition to teaching the science curriculum, we try and pepper in as much technology as we can, but it's just impossible to cover everything that we need to. So, to add something else, we wouldn't be able to. (A2-MS)

Teachers consistently cited *developing and making available appropriate resources* (Appendix C, row 12) as one of the primary negative motivators for considering the NGSS. Specifically, a lack funding and time to learn about the new standards was cited. One teacher stated, "You cannot force me to implement something new and not give me the time to delve into it with my peers; with my co-workers as a team, so that we can figure out what is the best way to present this material to children" (B1-ES). Another teacher commented, "Um, time would be the

big one to sit and be able to plan with my colleagues and brainstorm ideas…"(A2-MS). The teachers did feel that funding and time to work on new curriculum was a problem even if new standards were being considered, but given the complexities of the NGSS, teachers felt that this was a real negative motivator in considering adoption and implementation.

A final trend that emerged from the teacher interviews was the fact that adoption of the NGSS was particularly stressing the elementary school teachers, causing *standards fatigue* (Appendix C, row 4). In addition, there was previously not strong *value placed on science education* (Appendix C, row 14) with this particular grade band level. Part of this stress can be attributed to the Common Core State Standards for English Language Arts and Mathematics; they felt they were being overloaded with standards since they need to teach all subjects to their students. As one elementary teacher stated, "we have so many things that are pulling us right now. Common core for ELA is huge" (B1-ES). Another reason is that elementary school teachers are held accountable for their students' math and ELA scores, not their science scores, so the NGSS are seen as an unnecessary burden on the elementary school. The same elementary teacher noted,

> I think one of the things that's going to make it very difficult for anyone that is a self-contained teacher, meaning they teach all subjects…right now all…anybody in any state cares about is the national test and the national test that any state ever gives that I know of is reading and math. And so I think that the problem is going to be in the implementation, is when you get our self-contained folks saying 'Next gen, that's all well and good. However, when I'm evaluated, it's on my math and my reading scores. So guess what? I'm going to do what's going to keep me a job.' And that's where I think there's going to be the biggest problem in the implementation. (B1-ES)

Indicators of Epistemology

When analyzing the teacher data on epistemology it is important to carefully consider the context and the detail each interviewee provided as it relates to the indicators of epistemology at

this school/teacher level. Initially, it appears that the teachers interviewed had a very strong appreciation for how epistemology was outlined in the NGSS; all eleven teachers interviewed commented on the practices section of the document and the data indicate that the teachers referenced epistemology or used epistemology a total of thirty-six times. While it is true that the teachers were referencing and using epistemology in their interviews, the quality of their responses differed from how the District Coordinators were responding, so to present this simple frequency count is deceiving. A careful look at the data reveals that there were three teachers, B2-HS, B1-MS and B3-HS, who seemed to be very well informed of the NGSS project, referenced epistemology, and used epistemology more so than any other interviewee at any level. These three teachers account for twenty-three out of the total of thirty-six comments that were coded for referencing epistemology and using epistemology, and there comments were often much more in line with the detail provided by the District Coordinators.

The notion of epistemology arose thirteen additional times with other teachers, but the context was always around the desire for new or additional *professional development to support implementation* (Appendix C, row 40) that teachers' felt they needed to teach the standards successfully. As one teacher stated,

> the thing that I like about them and what motivates me to want to…to want to, I guess, follow them for lack of a better word, is we're so used to teaching curriculum right now that is a mile wide and an inch deep and <u>what I've seen in Next Gen is more of taking the curriculum and delving into it deeper so that way our students can have more of an application knowledge of it instead of just a basic recall of it.</u> (B1-ES)

Whilst referencing the need for professional development, another teacher stated, "Maybe working more on, you know, claims and evidence, or different…like kind of pictures what it would look like in the classroom I guess, you know. Just kind of modeling it." (A2-MS). Similarly, another teacher stated,

> I think the biggest thing that the teachers would need, not like physical things, but

just, I think, training. How to teach kids the bigger picture. How to question kids. You know, if it's Socratic questioning or Socratic circles. Trying to just ask higher level questions and get the kids to think as opposed to giving them all this information and expecting them to just regurgitate it, but be more of like an aide on the side and let the kids do the thinking… Whereas now the focus is more, get the kids thinking, get their ideas, let them brainstorm, and ask them questions to get them to different thoughts and connections. (B3-HS)

Many of the other comments that teachers made showed that the teachers as a group felt that the NGSS would require a "different" type of instruction than what has been the norm for teaching science courses. Further, teachers commented on how this "different" type of instruction would result in students' having a more in-depth understanding of and ability to apply science knowledge, but, similar to the SSCs, they did not clearly articulate how the practices focus students on how scientific knowledge is constructed in the same ways that the District Coordinators did. For example,

It's a whole other way of thinking for these kids. And I think that…our country as a whole is kind of moving towards those engineering [practices], you know, that type of work and everything. And I think, starting with elementary, I think getting the kids to think this way and to get interested in this stuff really opens up, you know, so many possibilities for them. And it really…they have fun doing it. You know, I give them a project, like we're working on…we're working on force and motion. You know, they're building…or energy transfers. We were building roller coasters. It's just, you know, being able to do fun things like that and learning at the same time. I think seeing them so interested and so excited to come to a STEM class…you know, with them learning about all these concepts, and, you know, just seeing them excited about it, excited about learning. (B3-ES)

It is clear from the quote above that this teacher is aware of a difference between the NGSS and other standards documents, at least as it relates to the integration of the practices.

This teacher focuses on how the practices require a different instructional model than what is traditionally taught, and how this type of learning, “opens up… many possibilities” for students, but, this teacher provides no additional details about what these possibilities are. Interestingly, the original question from the interviewer asked about how the practices motivate this teacher to implement the NGSS, but the teacher choose to specifically call out the engineering practices. It is unclear if this is because the teacher is confused about the practices outlined in the NGSS or if he/she is trying to make a larger point about something specific to the engineering practices. After the quote above the teacher abandons the thought on engineering practices and moves the conversation in another direction. Also, despite the focus of the question being on what motivates the teacher to teach the practices, he/she chooses instead to focus on the motivation of the students. In doing this, the teacher does not address the original question and talks about the practices in very broad terms without articulating any specifics about what motivates them as a teacher to implement the practices.

The three teachers considered to be well informed about the NGSS, B2-HS, B1-MS and B3-HS, did comment more specifically on the practices and had also reviewed the NGSS while they were in draft form. These three teachers’ comments were much more in line with the level of specificity provided by the District Coordinators, and reflected an awareness of the notion of epistemology and the role that the science practices play in the NGSS. They were also able to clearly articulate how the science practices were a fundamental shift from previous standards documents. These three teachers demonstrated that they were able to think outside of their own classrooms, and were able to take a systems perspective about how the standards might impact education in general and the learning of their students. For example,

> I think that, you know, we have three levels of science classes: biology, physics, chemistry. So you know we say, well these are the kids that are special ed, these are kids that are general ed and these are the kids that are advance and we kind of stick them in these levels, and each level is very different because of the nature of the kid. With the practices I think we're going to see that kind of go

away a little bit only because these kids will have less of this drill and kill content and more of application and applying practices; designing, developing, implementing, rather than just memorize this vocabulary or do these math problems. I think they'll see it more as a process instead of memorize for the next test. (B2-HS)

One of the other three teachers enthusiastically described an app he/she built that explores a students' understanding of claim, evidence, and reasoning in ways that are very similar to the NGSS practices.

We developed a pretty interesting app, I won't bore you with all of the details, but we have been looking at claim, evidence and reasoning, and the kids right there um, create claim, evidence, and reasoning statements from the data they have collected. They can collect data, they can annotate it, they can collect a video or picture, they can use a text, um, and then they can connect their, their data, their evidence from what they have collected on the iPad, whether it's in a classroom, in the field, or in a museum to write their claim, evidence, reasoning statements. And we've seen a lot of growth over the past three years (B1-MS).

The comments from these three teachers reflect a more sophisticated understanding of the practices in three ways. First, these comments contain more specificity, and include direct evidence that they understand the science practices. For example, the first teacher is able to identify the verbs outlined in the science practices and describe how these practices will lead to a greater application of science knowledge. This teacher even references how this may lead to more equitable expectations for students of varying ability. When prompted by the same questions as all of the other teachers, these three teachers' comments contain a degree of specificity not found in any other teachers' responses which may be evidence that they have a deeper appreciation of the science practices and the notion of epistemology that the NGSS outline. Second, these three teachers seem to be self-motivated to work with the practices, and seem to have prior knowledge of the practices outlined in the NGSS. This is evident from the

second quote where the teacher has been working on an app for his/her students to encourage them to work with, “claims, evidence, and reasoning.” Third, these three teachers seem to appreciate the integration of the science practices from multiple perspectives. They can speak to how the focus on science practices effects their curriculum and models of instruction as well as how their students’ learning is likely to benefit.

Key Findings

Key Finding 1

As the District Coordinators are uniquely situated within the state education system to be able to see both the on-the-ground practical implications and the high-level policy pressures of adopting and implementing the NGSS, they reflect the deepest level of awareness of how to best advocate for adoption and implementation of the NGSS.

Advocating for change in this research refers to how participants at each level plan to act towards the adoption and implementation of the NGSS or aspects of the standards that are different from the current state standards. It is important to note, while there are similarities between the primary code for advocacy and the primary code for motivation, these are decidedly different codes. On the one hand, advocacy is the evidence of **how** members at each level advocate for the NGSS. Motivation, on the other hand, is focused on **why** members at each level advocate in the way they do. When considering advocating for change in this way, two similarities emerged from across the three levels. Both of these similarities were related to strategies for implementation; the first is *provide professional development to support implementation* (Appendix C, row 40) and the second is *create/organize resources* (Appendix C, row 42).

By far the most cited implementation strategy across all of the levels was *provide professional development to support implementation* (Appendix C, row 40). This strategy was discussed by all but three of the nineteen interviewees for this research (one teacher (B2-HS), one District Coordinator (A3-DC), and the SSC from state B). However, the nature of the teachers’ and the SSC’s responses differed greatly from the District Coordinators. For example,

one teacher stated, “I think there should be professional development from the district for teachers and for building administrators. And I think the state is also going to need to run some professional development, whether it's through district leaders or also to reach out to teachers” (A1-HS). In a similar statement, the SSC expressed the following,

> We've always done a big push to raise awareness and help people understand what the standards are, so that kind of awareness outreach, we've always have that kind of thing. But it's rarely gone beyond that. Well I shouldn't say that. We have traditionally supported some professional development around the new standards as well for several years after the standards are adopted, and we'll do that again this time… But what we're able to fund for professional development from the state level is pretty minor compared to the range of professional development that's both needed and that actually happens in the districts. (SC-A)

While the teachers’ and the SSC say that providing professional development is the strongest way to advocate for the NGSS, they fail to give any specifics on how this would be helpful. The two quotes above are representative of the statements made by many of the teachers and the SSC around providing professional development to support implementation. In comparison, all but one of the District Coordinators demonstrated that they were already thinking through how implementing the NGSS might affect various parts of the system. For example, one District Coordinator reported that he/she preemptively began pulling together groups of teachers to help inform a possible implementation strategy. So, when the interviewer asked, “What resources will the district provide, or is preparing to provide, to support implementation of the new standards,” this District Coordinator was fully prepared to answer. He/she said,

> It's PD. It's opportunities for teachers to have a say. We'll help teachers unpack those together. You know, we'll do all that work together. We'll identify and develop curriculum. And identify and select, and hopefully provide instructional materials that will align to the new standards. ... it really kind of ramps up the possibility of teachers choosing to move towards that. (A1-DC)

When pressed further on how this District Coordinator was thinking about including teachers in preparing for the NGSS, the District Coordinator stated,

> We ask [teachers] about what PD do they think they need. So, what are some of the short-term PD shifts we can make? What are some of the long-term PD shifts we'll have to make? We ask them about how do we communicate the message and what are the kinds of things that need to be communicated? We ask them, what does the new vision for science teaching and learning look like? Cause they just spent two days in the standards. We did this as a wrap-up. So once they've read through sections…they did…they looked horizontally, kind of across a grade level or a high school course. And then they worked in a different group looked vertically along a content strand, or a…they called them Disciplinary Core Ideas. So they looked at the learning progression under…for one area. And so, they kind of…and then they looked at all the crosscutting concepts and they looked at the…through the appendices that kind of target some of the challenges for ELLs[3], SpEd[4],…teaching all children. That kind of thing. And so we wrapped up asking them what they thought the next steps would be. What the district next steps would have to be. How they'd need to be supported. What ideas they had for this. What excitement was there wrapped up in this. How can we sell it. And so we really tried to contextualize some of the whole picture, instead of just what's wrong, what's troubling. What's exciting. It's like, you know, you've got to kind help them paint the whole picture of what it will look like when we're there. And that's that vision, that vision piece for what students…how students will be different when they graduate, how they learned standards this way. All these standards. And then in order to get kids to that place, what does teaching and learning have to look like to get there. And then you back up from that to what

[3] ELLs – English Language Learners
[4] SpEd – Special Education Students

materials need to pull into…blah, blah, blah…do you need to do that. So…so that's kind of what we thought about. (A1-DC)

In this example it was clear that this District Coordinator was able to see the education system from a perspective that was different than the SSCs and the teachers. This perspective allowed for a level of specificity that the SSCs and teachers were simply not providing in their interviews.

Another notable difference between how educational governance at the state and school/teacher levels differed from the District Coordinator level when advocating for the NGSS was related to comments made about creating and organizing resources. Interestingly, when discussing the creation and organization of resources the teachers and the SSCs made more comments related to adapting existing materials than in the creation of new materials. It appeared that both the SSCs and the teachers were interested in ways to leverage what they have been using in their state and wanted to find ways to take this existing material and show alignment to the NGSS. The general feeling was that if resources currently exist, then the amount of change necessary would not appear to be as big of a deal, and advocating for the NGSS would be seen as less of a burden. This was not because the SSCs or the teachers felt that the NGSS was too great a burden, but they were afraid that others might see the adoption and implementation process as too big a change to the system. As one of the SSCs noted when describing his/her implementation strategy within the state, “the biggest difference will be around curriculum resources and trying to coordinate resources that exist out in the field, we've never done that before” (SSC-A). A similar comment by one of the teachers identifies the same desire to adapt curriculum. “Just to kinda do some brainstorming and lesson planning and getting ideas about how we can incorporate it into our already existing curriculum” (A2-MS).

This is not to say that the District Coordinators were not interested in adapting curricula that align to the NGSS; as the quote below shows, they were, but they also recognized that current curriculum would not suffice. This once again highlights a level of detail and depth of knowledge that was not demonstrated by participants at the other two levels. For example,

The curriculum development piece is interesting for us… we'll have to look to see

> what's there and then we might have to craft some things to kind of bridge what's there to what needs to be, I guess. So, we don't currently have a quote unquote curriculum in place. We have a lot of instructional materials that teach to the framework. But what I'm hoping is that we actually, in the end of this, have a real live, and I mean live like living being used, curriculum that includes a lot of high quality instructional materials, teacher support, assessment guidelines, technology connections, and actually bridges the science and engineering practices to the content and crosscutting concepts (A1-DC).

Another important shared understanding worth noting was that teachers and District Coordinators had low expectations that the state would help with funding related to implementation of the NGSS. High school teachers appear to be almost exclusively discussing the standards with the districts, not the states. The teachers had very low expectations regarding receiving any professional development or funds from their state, and they seem disenfranchised by the communications they receive from the state in terms of the NGSS implementation. Of course, neither of the states in this study had actually adopted the NGSS when the interviews were conducted, but both states did publicly state that they were considering adoption of the NGSS (a requirement of their being considered "lead states" in the NGSS drafting process). Even so, many of the teachers seem so disconnected from the state that they were unable to offer how the state might support them if new standards were implemented, with several of the teachers commenting on how they were relying in the District Coordinators for help; help with professional development, help with new curriculum, and help with getting information about what is happening and when. When the interviewer asked, "in what ways does or will the state support your implementation of these standards at your school?" One elementary school teacher responded, "The state? I have no idea" (B1-ES). A high school teacher echoed this sentiment as well,

> Oh, I don't know. I don't know that we receive a lot of state support, to be honest with you. I haven't noticed that. …But we're being told at this point that they're

going to roll out these standards and there really isn't a lot of money coming to support the roll out of the standards (B2-HS).

It appeared that the SSCs and others at the state are aware of how the District Coordinators and teachers perceive the situation. The SSC in state A confirmed, “what we're able to fund for professional development from the state level is pretty minor compared to the range of professional development that's both needed and that actually happens in the districts.” (A-SC).

Key Finding 2

Motivation to adopt and implement the NGSS is highly nuanced. The most significant factor influencing motivation to adopt or implement the NGSS at each level is related to assessment. The reasons assessment affects motivation is different at each level.

a. *At the State level, assessment affects the motivating factors to adopt and implement the NGSS in the **positive** direction because it is a way for the SSCs to have agency over the education system. The SSCs note that they have limited authority in influencing the adoption and implementation process from anything other than high-level policies directly related to state assessments.*
b. *At the District Level, assessment affects the motivating factors to adopt and implement the NGSS in the **negative** direction because the District Coordinators believe that state assessments set exceedingly rigid guidelines that limit the authority at the district level. In addition, District Coordinators are concerned with how teachers and schools might be evaluated using state determined assessment.*
c. *At the school/teacher level, assessment affects the motivating factors to adopt and implement the NGSS in the **positive** direction because teachers are extremely concerned about fair and equitable teacher evaluations. While teachers are concerned about how the changes will impact their students, they are most concerned with how their students’ assessment may impact their own performance evaluations.*

The most notable similarities between the levels in terms of motivation were around *factors effecting change* (Appendix C, row 15) as they related to *assessment* (Appendix C, row16). At the state level, assessments were seen as a way to motivate districts, schools, and teachers to change their curriculum and professional development, without overstepping their authority in such matters. Given that the states in this study are local-control, the state cannot dictate, or even suggest in some cases, how districts and schools should make decisions on the type of curriculum to implement and/or the type of professional development to provide for teachers. Because of this, assessments are a very powerful tool that the SSCs have and they carefully use it to help implement their preferred policies. As one SSC put it,

> To motivate or compel districts, the only way we can compel districts in [State] is through the state assessment, and through our school and district accountability system. Every school and district has to administer the state assessment. Students don't have to pass them, necessarily, for example they do not count toward a decision of whether the student goes forward to the next grade, but there are some graduation expectations tied to that. (A-SC)

At the district level, assessments negatively motivated the District Coordinators as they were seen as both a burden imposed by the state, and as a possible inapt teacher evaluation tool. District Coordinators expressed that the state assessments were seen as barriers to some of the policies that they would like to implement or support, and it appeared as if the state level assessments were a point of contention with many of the District Coordinators. For example, one District Coordinator stated,

> Well, if the state is going to tie proficiency and whether or not schools are meeting the state expectations for them…if all of that is going to be continued to be tied to student success on state exams then you can say that this is local control, but really and truly the state is holding all the cards. They're holding the funding. They're deciding what is going to be on those high stakes tests. And then they're publishing in the newspaper and they're calling schools

successful…or success or failure based on those test results. So, the state is really determining what districts do. (B2-DC)

While District Coordinators recognize the power that the state assessments have given the SSCs and the state level, the District Coordinators are still able to set graduation requirements and determine what a student will need to move on to the next grade. State assessments set an interesting balance of power between the SSCs at the state level and the District Coordinators at the district level. One area that seems to really concern the District Coordinators was how teacher evaluation would be tied to the state assessments. District Coordinators felt that if teacher evaluation was done well then the district level would be very interested in the data, but it was also clear that the District Coordinators felt that tying teacher evaluation to student performance on the state assessment would not provide valuable data.

> There'll be tensions around assessments. And another huge tension that I didn't think of earlier, but it's critical, is around teacher evaluations. So, our state now has a teacher evaluation policy where teachers will have the potential to lose their job based on [students] performance on standardized tests. So, when you talk about shifting all of these things, you're shifting practice, you're shifting assessment, you're shifting…it can have implications with teacher evaluation and teacher employment, which would also be added back under policies that are currently in place which could cause a barrier, would be the teacher evaluation system. (B1-DC)

At the school/teacher level, educator evaluation was the motivating factor that all of the teachers discussed. Many of the teachers expressed frustration with the current system of evaluation, and were skeptical that the NGSS was going to encourage a more fair system. Teachers also felt that any new assessments were likely going to be imposed on them, with little input from the school/teacher level. Teachers were also anxious because they did not believe they would be given adequate time to adapt to the new assessment system. One high school teacher in state A expressed the following with some angst,

I do think it'll be important to know when our assessment is going to be rolled out. What might the assessment look like? As much as I don't like teaching to a test, if I'm going to be evaluated…somehow held accountable by those assessments then I do want to know what they're going to look like and be like and what is…what are they saying; what's emphasized or is just here goes. (A1-HS)

When looking across the three levels, it is clear that there is a fundamental difference among how members at each level view the role assessments play and how assessments serve as a factor effecting change. Interestingly, each level seems to understand the relationship between assessment and policy, specifically NGSS implementation, in a unique way. The SSCs see assessment as being a positive factor effecting change, and they have expressed how assessments are one of the few powerful tools that they have to implement their preferred policies. The District Coordinators see assessments as being a negative factor effecting change. The District Coordinators are presuming that state level assessments will be seen as a burden by teachers and students and may in fact distract teachers from focusing on some of the more important aspects of the NGSS. The teachers are negative about assessments but they still feel that assessments will lead to change. The teachers seem apathetic about the relationship between assessments and policy, but they have expressed that they plan to teach to the test if this is what they are evaluated on. Ultimately, everyone wants to see the NGSS implemented effectively in the classroom, so if the SSCs are able to build high quality assessments that align very closely to the enduring understandings outlined in the NGSS, then it is likely that the teachers will implement a curriculum more closely aligned to the NGSS. If not, the concerns expressed by the District Coordinators may be realized, and the teachers will be less likely to teach to the NGSS.

Key Finding 3

Each interviewee at each level demonstrated awareness that the NGSS are significantly different from prior standards in some way. While teachers and SSCs sometimes cited the science practices as the critical difference, they were not able to meaningfully elaborate on what "science

practices" are. Conversely, the District Coordinators demonstrated a deeper level of awareness and were able to comment more specifically on the practices and how they would affect science education in their state.

It is clear that the District Coordinators are the most well versed of all the levels in their awareness of how the NGSS integrate and require students to work with the science practices. On the one hand, only two out of the eleven teachers made substantive comments about the practices outlined in the NGSS, and how these practices will refocus science education on this notion of science epistemology. One other teacher never brought up the science practices at all. The other eight teachers' comments were of a different nature. They expressed anxiety about having to implement the science and engineering practices into their curriculum and many of their comments centered on a desire to receive more examples or professional development to help inform their curriculum. For example, the elementary school teacher's statement below is an example of a teacher knowing that something is different and knowing that this will impact his/her curriculum and teaching, but struggling to articulate exactly how.

> That's the kind of…that's the kind of professional development…that's what I need. I need someone to take the standard and say, okay here's the standard. This is the experience you need to give the kids. For example if we're doing something in physical science and kids are learning about light energy. And so the standard is da-tada-tada about light energy and if you want the kids to meet the standard, here is the experience you provide. You do this activity with mirrors and flashlights and then you lead me through the experience. (B1-ES)

On the other hand, District Coordinators noted how significantly different the NGSS are from previous standards efforts and described ways that curriculum and assessments will need to change in response to this shift in much more detail than the other two levels. One District Coordinator, when asked about what they saw as one of the greatest needs that implementing the NGSS would require, stated, "high quality assessment that does not just discuss content and minutiae but actually assesses what we truly value in science and engineering, which are the

practices" (A1-DC).

The examples above, as well as the quotes from each level that relate to coding for *referenced epistemology* (Appendix C, row 52) and *used science epistemology* (Appendix C, row 53), highlight the difference between the District Coordinators' level of appreciation of the science practices and the teachers and SSCs level of appreciation of the science practices. Notwithstanding the three teachers that were the exception at the school/teacher level, the District Coordinators exhibited a deep level of appreciation of the science practices. Also, the District Coordinators ability to cite specific components of the document that related to the science practices, as well as demonstrate ways in which curriculum or assessment would need to change was clearly more facile than the other interviewees at the other two levels.

Key Finding 4

Regardless of level, the better a participant reflected an awareness of epistemology, the more likely they were to advocate for adoption and implementation of the NGSS. Similarly, the better a participant reflected an awareness of epistemology, the more likely they were motivated to consider adoption and implementation of the NGSS.

Another interesting finding when looking at how epistemology is discussed across all levels is that an interviewee, regardless of level in the system, was much more likely to advocate for the NGSS and much more likely to be motivated for implementation if that interviewee also made comments that were coded as *referenced epistemology* (Appendix C, row 52) or *use of science epistemology* (Appendix C, row 53). This finding emerged from analyzing the code co-occurrences. An interview that was coded with *referenced epistemology* or *use of science epistemology* was also coded for *reasons motivated for* (Appendix C, row 48) 93.3% of the time. An interview that was coded with *referenced epistemology* or *use of science epistemology* was also coded for *advocating for* (Appendix C, row 44) 86.7% of the time. As one high school teacher said;

> I love the idea of inquiry-based science education. So that's kind of why I'm interested in the standards. Also from the perspective that I am department chair

in my building. A lot of our teachers are kind of reluctant to change. But I think it's a very good way these engineering practices have been developed. I think it's a really good way to present science; to teach science. I think that with [state standardized test] and the standardized testing being a little more problem based learning, the standards support that. So it gets kids a little more involved in actively thinking through procedures than just memorizing that rote education that we've been giving them more that drill and kill science education. (B2-HS)

As this teacher notes, the NGSS provide ample opportunities to engage in science epistemology. This teacher also notes how motivating this can be for students and how "reluctant" many science teachers are to changing the way they currently teach. The quantitative data presented succinctly indicates the existence of a strong positive relationship between the awareness of epistemology and advocating for and motivation to consider adoption for the NGSS. It also suggests that at all levels (i.e., the state, district, and school/teacher levels) an the awareness of science epistemology plays a larger role in the decision to advocate for and motivation to consider adoption for the NGSS than any other factor.

The findings from this research show many overlapping themes that emerged in the responses provided by the SSCs, District Coordinators, and teachers with regard to strategies and challenges for implementing the NGSS. These overlapping themes shed light on the nuanced differences among members of each level and their perspectives on advocating for, and motivation to implement the NGSS. The four key findings gleaned from the data reveal the varying ways in which each level grapples with the relationship between educational standards reform efforts, such as the NGSS, and the policies needed to support these efforts. The main themes of student assessment, (and how it relates to teacher evaluation), professional development for teachers (especially as related to creating and organizing resources) were important to all three levels though they were perceived from each levels' lens of perceived responsibility and agency.

CHAPTER FIVE:
Discussion

The aim of this study was to describe the three levels of the education system within a local control state – 1) the state level, 2) the district level, and 3) the school/teacher level – and how each level supports or hinders the adoption and implementation of the NGSS. Data has been analyzed to determine what motivates members from each level to consider adoption and plan for implementation, who is advocating for or against adoption, and what role science epistemology plays in the decision making process to support or not support the NGSS.

The focus on local-control states highlights some of the most difficult implementation issues that large scale science education reforms face, specifically that a number of actors are involved in the decision making process at various times and to varying degrees. This research is important because there is a dearth of knowledge about *how* science standards are implemented. Currently, little research exists on how decisions are made in local-control contexts when it comes to considering change and adoption of new educational reform efforts, especially science education reforms, and what ultimately compels or motivates these stakeholders to consider a change or how much to change (McEver, 2010). Similarly, there is a lack of information regarding how stakeholders working on major reform efforts in science education, specifically the NGSS in this case, navigate state, district and school/teacher level policies. Moreover, not much is known about who the players are, how understandings (such as scientific epistemology) are transferred from one level to the next, and very little research has been conducted regarding the roles each of these stakeholders have in the final implementation of educational reforms such as the NGSS.

Key Findings

Each of the four key findings from this research, which were presented in chapter four, is discussed below in more detail. Each key finding is connected back to the literature presented in chapter two. In this discussion section, each key finding will also be explored to determine what new knowledge can be harvested.

Key Finding #1

As the District Coordinators are uniquely situated within the state education system to be able to see both the on-the-ground practical implications and the high-level policy pressures of adopting and implementing the NGSS, they reflect the deepest level of awareness of how to best advocate for adoption and implementation of the NGSS.

One of the more surprising findings was how little influence the state-level science coordinators had on the adoption and implementation process of the NGSS. One of the assumptions going into this research was that the SSCs' proximity to many of the most important decisions makers in their state (i.e., the Governor, the Chief State School Officer, etc.) would give them significant power in affecting the adoption and implementation process directly without the support of the District Coordinators. Despite this, both SSCs commented that while they were in favor of adoption, they felt the decision to adopt would be mostly outside of their control. It appeared that the District Coordinators had more influence over what was happening at the state level then the SSCs. Rather than directly dealing with standards and curriculum on a day-to-day basis, which were not proximal to their regular activities, the SSCs seemed to be more in charge of funding, state assessments, and the allocation of resources.

One possible explanation is that the extent and nature of the access that each level of the education governing system has to the other levels greatly influences their perspective of the other levels. The fact that the District Coordinators were situated in the middle between the state and school level seemed to provide them with the widest frame of reference on the standards adoption and implementation process. The District Coordinators proved to be quite knowledgeable when it came to the political pressures that influenced the SSCs at the state level, as well as an understanding of the practical issues that the teachers face at the school/teacher level. This also coincides with what others have claimed in the literature (Walberg, 1992); states that are considered to be on the "local-control" side of the spectrum have more stakeholders in the education policymaking process, and these stakeholders are found at more levels (i.e., state level, district level, school/teacher level). These stakeholders in local control states also perceive

a greater stake in the overall system (Walberg, 1992). Because the NGSS are significantly different from other state standards, it is possible that the District Coordinators discern that the NGSS will be a greater disruption to the way science is currently taught and therefore feel a need to take on a larger role then the SSCs. This would also be in line with claims by Strang (1987), who notes that local-control states often have less bureaucracy and more autonomy when compared to more centrally controlled states.

Similarly, Spillane, Reiser, and Reimer's (2002) research on sense-making and the cognitive framework of implementation may help to explain why the district coordinators play such a large role in the implementation process. It is important to note that in the case of the NGSS, the standards were written at the national level. These standards were then passed down to *not only* the state level, but all levels simultaneously. This is not a linear process, going from the state level to the district level and from the district level to the school/teacher level. Instead, by each level being given access to the standards simultaneously, all levels had the ability to collectively influence state policy around the standards. In this way, each level is required to be a sense-maker of the NGSS and inform their ideas of what a successful implementation process might look like. What this research suggests is that in a local-control context, the District Coordinators have a perceived, and possibly actual, greater agency in the process that makes them the strongest influence in setting policy. It also appears that they have the perspective of both the teachers and the SSCs, which gives them the broadest possible lens to make sense of the document and the policies needed for successful implementation. Ultimately, the sense-making of the District Coordinators influences the way in which the other levels seem to come to understand the NGSS and perceive the overall implementation process.

Walberg's (1992) research also showed that teachers and school administrators should perceive a greater stake in the education policymaking process as well, but this study does not support that conclusion. In this case, the perceived effect seems to be concentrated at the district level and does not penetrate down as far as the school/teacher level. It is conceivable that this is because teachers, as they noted in the interviews, have a full plate teaching students and, "can't

always keep up with the latest national initiatives" (B1-HS). Teachers' motivation may also be affected by feeling disconnected from the state and that decisions are made upstream of them with little to no input. It is possible that this feeling of being disenfranchised has influenced their perception on their stake when it comes to adopting the NGSS.

Key Finding #2

Motivation to adopt and implement the NGSS is highly nuanced. The most significant factor influencing motivation to adopt or implement the NGSS at each level is related to assessment. The reasons assessment affects motivation is different at each level.

There are many documents that have called for a close link between large-scale state assessments and standards. *A Nation at Risk* (1983), *Rising Above the Gathering Storm* (2007), and the most recent iteration of the Elementary and Secondary Education Act, known as No Child Left Behind (NCLB; 2001), have all called for policies directly linking large-scale student assessments to educational standards. While it should come as no surprise that policies around assessments are a major motivator for each level within the states, what was surprising is how very specific trends regarding assessment emerged at each level as a main motivating factor.

State Level

At the State level, assessment affects the motivating factors to adopt and implement the NGSS in the ***positive*** *direction because it is a way for the SSCs to have agency over the education system. The SSCs note that they have limited authority in influencing the adoption and implementation process from anything other than high-level policies directly related to state assessments.*

As previously noted, NCLB significantly increased testing in math and English language arts and added repercussions for failure to meet performance goals (Lazzaro et al., 2009). States were charged with measuring students' performance and given the power to label schools as passing or failing, as well as set the bar for what counted as passing or failing. As state politics have given even more control of the education system to districts and schools, especially in local-control states such as the ones that took part in this study, one of the major functions that

educational governance at the state level still performs is in setting large-scale assessments of students' performance with respect to standards. This function has proven to be a significant influence over the education system with numerous trickledown effects (Fuhrman & Elmore, 1990), and while it is not the most direct way to influence NGSS implementation, both SSCs interviewed for this study expressed how their ability to redesign state assessments does give them the ability to support the NGSS in ways that they would not otherwise have.

This research adds to our understanding of how large-scale state assessments coupled with standards can influence the top-down policies within state education systems. As has been noted in the literature (DeBoer, 1991), assessments have a significant influence in changing how a system of education operates. One needs to only look as far as the current No Child Left Behind Act (2001) to see evidence of the effects assessments have on curriculum, professional development and even resource allocation. The SSCs were excited that the NGSS were opening a conversation around science, and they felt that it was giving them an opportunity to change their current assessment systems to place more emphasis on science education, an opportunity that they would not have had if this national initiative was not put in front of them. It was clear that the SSCs believed that they could encourage schools to expend more resources on science education by adding to the current assessments and refocusing curriculum on what current research says are the more important aspects of science education. The SSCs also hinted at there being a risk that assessments can be a negative motivator towards advocating for the standards if it required them to recreate costly performance measures that narrow the curriculum to what is easily testable. This is not to say that the SSCs are shying away from creating standardized tests, they are not, but they recognize that others in the system, especially the teachers and the students, are very much against high stakes standardized tests as the only way to measure students' performance. This is akin to much of the criticisms that plague the No Child Left Behind Act (2001), specifically that high stakes standardized assessments play too large a role in determining student performance and teacher evaluation (NAEP, 2009; Kirsch et al., 2007). There was also a concern that focusing too much on science could take away limited resources

from math and ELA. At this point, both SSCs seemed to feel that this was not going to be an issue, but it was clear that if science required too much time and resources then this positive motivator could quickly turn negative.

District Level

At the District Level, assessment affects the motivating factors to adopt and implement the NGSS in the ***negative*** *direction because the District Coordinators believe that state assessments set exceedingly rigid guidelines that limit the authority at the district level. In addition, District Coordinators are concerned with how teachers and schools might be evaluated using state determined assessment.*

Again, the findings from this research extend our understanding of how assessments influence the motivations of people working at this level. Since the 1983 Gardner report *A Nation at Risk*, there has been an explicit call for high quality standards in science education. The NRC report also cites the need of linking accountability of states and schools to student assessments that align to these standards, and describes how doing this allows one to measure the success of the reform effort. Twenty years later, it is clear that District Coordinators, while not referencing this report directly, were all aware of the recommendations it contained and were working towards the vision that it outlines aside from the NGSS. As has been mentioned, the District Coordinators were the most well-informed, strongest advocates, and most highly motivated group towards full implementation of NGSS of all three levels. Yet, they still felt that assessments were the key component motivating them to adopt and implement the NGSS. The District Coordinators' focus on assessment, similar to the SSCs, was strongly tied to their primary function within the education system — specifically, to collect data on effective teachers and improve curriculum and student learning. This level of detail around what is specifically motivating District Coordinators to consider a national standards effort within a local control context is not included in any of the educational research. Interestingly, much of what motivated the District Coordinators about assessment in general was that they believed it allowed them to more efficiently perform their jobs by aiding them in making curricular and professional development decisions, but they were

not as convinced as the SSCs that assessments were the most effective way to drive student learning. The District Coordinators stated that student learning was best served by high quality professional development and working directly with their teachers, which aligns with the Kingdon and Thurber (1984) research on how children are educated within large-scale education systems. This research adds to the Kingdon and Thurber (1984) research in that this research identifies a major concern for District Coordinators that is centered on how assessments are going to be created and whether or not these new assessments would constitute fair measures of students' knowledge and teachers' performance. This research found that not only were District Coordinators concerned about assessments, but that they expressed a willingness to spend time and resources to ensure that the assessments were of high quality and would measure students and teachers fairly.

School/Teacher Level

At the school/teacher level, assessment affects the motivating factors to adopt and implement the NGSS in the ***positive*** *direction because teachers are extremely concerned about fair and equitable teacher evaluations. While teachers are concerned about how the changes will impact their students, they are most concerned with how their students' assessment may impact their own performance evaluations.*

Most of the teachers interviewed expressed feelings that the standards, should they be adopted by the state, would be adopted with little input from the school/teacher level. Given their perception of lacking a voice in the adoption process, teachers felt that the standards would be imposed upon them regardless of their viewpoint. Again, this research contradicts Walberg's (1992) research, as one would expect to see teachers in a local-control state, with their perceived greater stake in the education system, more highly motivated to provide input to the new standards and feel that their voice in such matters should make a difference. Instead, this research shows that teachers were so concerned about how their students' test scores on state assessments might be tied to their own performance evaluations that this prevented them from fully engaging in the NGSS and contributed to their feeling little agency in the adoption or

implementation process.

Considering what we know from Elmore's (1980) research, there is possibly more that can be deduced from the teachers' interviews. While teachers are not necessarily opposed to, or have negative motivations towards, the adoption and implementation of the NGSS, their general apathy in the process is notable. Despite several teachers being directly involved with the construction and drafting of the NGSS, for the most part the NGSS, as most educational standards, are a top down process. That is to say, policymakers work with educational leaders to draft a set of standards that are then passed down from, in this particular case, the national level to the state level, and then to the district and teacher levels. Elmore would describe this as a forward mapping process and his research suggests that it is possible that national and state policymakers may not be sufficiently aware of the needs of the end users, in this case the teachers. On the one hand, most teachers see state assessment policies as a negative motivation due to their concerns that such assessments might impact their curriculum, and they would have little time to learn about, and implement the appropriate changes. Teachers also expressed concern that they would not receive enough professional development to learn how to effectively teach to the new assessments and that they would have no real say in how assessments should be constructed. On the other hand, teachers felt that assessments could be seen as a positive motivator if done well. These teachers felt fairly comfortable with the NGSS and thought that being held accountable towards high quality standards, which they all agreed the NGSS are, would challenge them to rethink their curriculum and their own practices, but only if the assessments were fair and aligned to the NGSS appropriately. From a backwards mapping perspective, it is possible that policymakers would have benefited from outlining what new assessments might look like prior to releasing the NGSS. I am not suggesting that it is necessarily feasible to design assessments and curricular activities with teachers prior to implementing the NGSS, but this research does suggest that this may help address the needs of the teachers and allow them to be more motivated to engage in the process.

Key Finding #3

Each interviewee at each level demonstrated awareness that the NGSS are significantly different from prior standards in some way. While teachers and SSCs sometimes cited the science practices as the critical difference, they were not able to meaningfully elaborate on what "science practices" are. Conversely, the District Coordinators demonstrated a deeper level of awareness and were able to comment more specifically on the practices and how they would affect science education in their state.

As noted in the findings, all three levels discussed science epistemology but the district coordinators and the aforementioned three teachers did the best job at clearly articulating how science epistemology represents a significant change in the NGSS over other standards documents. The other teachers stated throughout the interviews how the NGSS are different, but they were only able to articulate a vague notion about what is so different about these standards. For example, they might be able to discuss the complexity of a performance expectation in the NGSS, but they showed no evidence of being able to pinpoint that it is the science practice merged with the core disciplinary idea (i.e., content) that has shifted the emphasis of learning towards this science epistemology. This is similar to what was noted in the literature (Duschl et al., 2007), specifically that defining science practice is difficult even for researchers, and that the term "science practices" and its relation to science epistemology is amorphous and continues to evolve. Instead, just as the researchers prefer to give examples of science practices and how they are used as ways to describe and express what is meant by a science practice (Duschl et al., 2007), the SSCs, District Coordinators, and teachers all did the same thing. The SSCs and teachers especially were not able to clearly articulate their burgeoning appreciation of what is encompassed by the term "science practices." For example, this was revealed by many of the statements that participants from both levels made around a need for a way of teaching science that was "different." Interestingly, teachers often commented on the need for professional development that would specifically give them examples of experiences or experiments that they could include in their curriculum. They wanted these examples to include a focus on the

integration of the practices with the core disciplinary ideas (i.e., the content) to show how their teaching style and curriculum might change, and to provide context for how they might integrate a greater emphasis on students learning about how science knowledge is constructed.

Providing context around the standards was something that participants at all levels in this study discussed. It is understandable that at the school/teacher level, teachers' repeatedly asked for specific examples, as this level is responsible for enacting and putting into practice the NGSS in their classrooms. However, many of the state and district level interviewees also expressed a desire for the same examples. Many participants at the state and district level seemed to want these examples because they were unclear about how a specific practice was suppose to be taught or assessed. Often times, their comments were more conjectural then practical. It should also be noted that many of their questions are addressed in the NRC Framework or in the front matter of the NGSS. It was clear that much of the confusion around epistemology that participants at all levels had did not require greater context, it required emphasizing what was already outlined in the framework under chapter three (Dimension 1: Science and Engineering Practices) and chapter nine (Integrating the Three Dimensions). Additionally, attention to appendices A (Conceptual Shifts in the Next Generation Science Standards), F (Science and Engineering Practices in the Next Generation Science Standards), and H (Understanding the Scientific Enterprise: The Nature of Science in the Next Generation Science Standards) would have helped clarify their confusions. I state this not to criticize the participants in this study for not reading the Framework or NGSS carefully, but to point out that despite many of the participants being familiar with the standards, few of them showed evidence of having read and understood the supporting documents (such as the *Framework* or Volume 2 of the NGSS which contains the appendices).

Key Finding #4

Regardless of level, the better a participant reflected an awareness of epistemology, the more likely they were to advocate for adoption and implementation of the NGSS. Similarly, the better a

participant reflected an awareness of epistemology, the more likely they were motivated to consider adoption and implementation of the NGSS.

This key finding is unique, and extends our understanding of the literature in science education. While some of the literature stresses the importance of an awareness of science epistemology as it relates to ones' motivation for participating in the field of science (Duschl et al., 2007; Popper, 2002), how this awareness translates into motivation and advocacy as it relates to support and enactment of educational policy is a new and meaningful addition to the literature. However, this key finding must be discussed with extreme care. This is because it is easy to misinterpret this finding without the full context of the interviews. As was noted in Chapter 2, both the NRC Framework (2011a) and the NGSS contain a section on science practices and relies on research that places a strong emphasis on students' gaining a greater knowledge of science epistemology (although this label for the understanding is never explicitly used in either the Framework or NGSS documents). Given this emphasis, it seems likely that someone who values science epistemology would have a favorable view of the NGSS and therefore would more likely advocate for the standards or be motivated to implement them. This could account for the relationship outlined in the key finding and is evidence of the strong epistemological focus of the standards. In other words, if a standards document truly integrates science epistemology effectively, as the authors of the NGSS claim, one would expect to see this strong positive relationship, and we do.

Implications

The findings emerging from this research have the potential to make significant impacts on the field of science education. This research is most important for informing three main stakeholders in the educational governance/policy process: standards writers, policy makers, and school based employees (i.e., teachers and school administrators). First, this research highlights major questions and concerns that stakeholders of the standards have at each level. Therefore, this research may aid the standards writers, as it could help inform what supplemental materials they compose and how they disseminate this information to ensure it reaches their intended

audiences. Unfortunately, this research also suggests that much of the supplemental materials that were developed for the NGSS, which were intended to highlight the focus on science epistemology and ease the transition, have had limited impact. This research suggests that more time and effort should be allocated for creating a consistent message and targeting that message to various levels in the system that the standards writers are trying to effect – in this case the state, district, and school/teacher level. Standards writers should have a plan in place to get stakeholders at each level on board early and provide them with professional development built around science epistemology that is integrated into the standards. While there is a great effort now underway from groups such as the National Science Teacher Association (NSTA), Biological Science Curriculum Study (BSCS), and others to provide updates and web based professional development, this research suggests that these efforts could have begun long ago even before the standards were constructed in order to prepare stakeholders for the changes.

Next, this research is also important for policy makers, because so little is known about how these types of national standards reform efforts play out in states and who is impacting the major decisions at each level. The fact that, at least in the local-control context studied here, the district coordinators play such a crucial role is enlightening because, to date, national reform efforts have focused much of the attention on adoption of standards, such as the NGSS and the Common Core State Standards, at the state level. Also, the fact that teachers feel disenfranchised and the SSCs are limited to assessment as their main lever of change can help inform where to target future policies and add clarity to the policy decisions at each level. This research suggests that in order to aid teachers and to address their feeling disenfranchised, two intertwined issues need to be considered. First, teachers need to be better informed about the purpose of the standards, and how these standards will impact their classroom. Professional development that targets science epistemology, along with specific examples on how to integrate this directly into classroom materials, would go a long way in helping teachers understand how the NGSS fits into their curriculum. Second, addressing how teachers will be evaluated is also important. Currently teachers fear that their evaluations will be tied directly to their students' state

standardized test scores. This research suggests that addressing both of these issues could lead to teachers feeling more empowered and engaged with national standards reform efforts.

Finally, this research should also benefit school-based reform efforts. It should allow administrators and teachers a deeper understanding about how and where they can participate in state level policy discussion, and where their input could be valuable to this policy discussion. It should also help science teachers identify where they may have gaps in their knowledge about the standards, especially when it comes to epistemology and the science practices, and may assist them in more clearly articulating what could help them in advancing their appreciation.

Limitations

Given that this study is based on interview data and employs a phenomenographic research methodology, the ability to apply these findings more broadly to other policy reforms is limited. The primary reason is that this study focuses on a particular set of people's perceptions around adoption and implementation of a unique set of learning standards. The perceptions about national science standards in this study are bound in terms of time, location, and content, as well as the fact that both states that participated in this study were considered local-control states in terms of educational governance. All of this makes the data that was observed and analyzed exceptional to this particular study and limits this study's generalizability. Of course, it is still possible to learn from the categories or themes that emerged from the data analysis. It is also particularly relevant to analyze how policy-decisions are made at this particular moment in time, and related to this particular policy environment. While the findings of this research may not apply to all current or future situations, it does document a unique moment in the field when a national standards effort took place and had a major impact on science education.

In addition, the data used for this research were not collected for the sole purpose of this report and I did not conduct the interviews. While these data were well aligned to the research questions, the analysis and findings may have been limited by this fact. It is possible that interviewees could have been questioned further in some areas or that additional follow up questions would have shed further light on these research questions if the data were collected for

this sole purpose. For example, this study would have benefited from more targeted questions specifically related to interviewees' understanding of science epistemology, and how the practices frame science epistemology for all students.

Also, while every effort was made to have an even number of teachers from each district – rural, suburban, and urban – one of the teachers had asked that their interview be withheld at the end of the interview and several teachers were not able to participate after being recruited. Even though there were enough participants to provide a sufficient sampling of teachers, it is possible that a more even distribution of teachers across the rural, suburban and urban districts may have influenced the resulting findings.

Finally, as previously mentioned, I am not an outside observer when it comes to the NGSS. My current position at the College Board has afforded me an insider's perspective on many of the topics discussed in this dissertation. I have participated in planning meetings with the NRC framework committee members, presented to the NGSS writing team, and was commissioned by Achieve Inc. to write a paper on college-readiness as it relates to the NGSS. I have also participated in several meetings that were convened to discuss adoption and implementation of the NGSS at the state level. It is because of this insider's perspective that this research was possible, but I am very much aware that it may also affect the ways in which I have viewed the data and findings of this research. Given this, every effort has been made to remain objective throughout the research and writing of this dissertation.

Future Studies

There are numerous directions that this research can go. To start, there are many other players at each level that could be interviewed. For example, in this study the SSCs were the only people interviewed at the state level. There are many other state level actors that could have been interviewed such as the state superintendent, the director of the assessment division, the governor, etc. Similarly, at the district level, education support professionals or principles and school administrators at the school/teacher level could be interviewed. All of this would provide additional insight and allow sharper claims to be made about how each level is advocating for the

adoption of the NGSS and what is motivating them to do so.

One interesting question that arose from this study that I would like to explore further is whether or not principles and school administrators perceive a greater stake than teachers in the adoption process at the school/teacher level? For this study, teachers were the only representatives of the school/teacher level, thus it is not possible to determine if other representatives at this level (e.g., principals, school administrators, etc.) may have affected the results for this level. The data show that the District Coordinators have a perceived greater stake than the SSCs, which is in line with the literature, but the school/teacher level is also expected to have a greater stake than the SSCs and they do not. As I have speculated here, one possible explanation is that the teachers may not hold this perception because they are saddled with full teaching loads, which prevent them from following the latest national and state initiatives. To test this idea, and to see if this is true across all actors at the school/teacher level, it would be interesting to interview principals and school administrators. Principals and school administrators play a more central role in setting policy at the school/teacher level than the teachers themselves, so it would be interesting to explore if they perceive the adoption of the NGSS differently than the teachers and more like the District Coordinators.

Finally, I would like to explore if these findings change in states that are more centrally-controlled. As has been noted, there is no state that has a fully centralized system of education, but there are states that lie on the opposite end of the spectrum than states A and B, which were chosen for this study. Currently, there are states that are considering adoption of the NGSS that would fall into the “more centrally-controlled” category, so it would be possible to collect data. This would allow one to compare the findings from this study with the findings from a more centrally-controlled state to see if there is a difference in the adoption process or if there is a difference in motivation at the various levels. This would also broaden the impact a study of this type has and would allow for a fuller picture of how policies are adopted and implemented throughout the education system in the United States.

Conclusion

In conclusion, this research demonstrates how three levels of the education system within a local control state – 1) the state level, 2) the district level, and 3) the school/teacher level – supports or encumbers the adoption and implementation of the NGSS. This research also measures key understandings of members, what motivates them, and how they advocate for a national science standards reform effort. By doing this, this study sheds light on how decisions are made in a local-control context, especially when it comes to considering change and adoption of new educational reform efforts. Although further research is needed, this study identifies several key factors that compel and motivate these stakeholders to consider a change, or the rate of change that can be supported within their local policy environment.

The findings from this research also provide valuable insight into the role science epistemology plays at each level. It signifies the importance of contextualizing complex science education reform efforts to multiple stakeholders, in other words, making science education reform efforts more communicable and accessible to a wider range of audiences. It begins to identify how reforms must navigate multiple, and sometimes competing, interests before they become realized policies. The findings of this research will also aid the field of science education in targeting their approach to future reform efforts. While further research is still needed, this study betters the field of science education's knowledge on how reforms are dealt with by those we are so often trying to help.

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APPENDICES:
Appendix A

Email communication – Recruitment letter

Source, Sevian, 2012

Dear X:

We would like to invite you to participate in a design-based policy research study to understand implementation and provide feedback to implementers of the Next Generation Science Standards (NGSS) as they roll out. In particular, we are studying how large-scale reform takes place in local-control States. We will be studying two States closely - with State science coordinators, district science coordinators, and teachers in Massachusetts and one other focal State, and we are also asking the State Science Coordinators of four additional local-control States to participate.

If you agree to participate in this study, you will be participating in an iterative process where we will conduct four rounds of interviews and collect artifacts from you over three years. In between each round, we will analyze the data and provide feedback to you on what we are learning, in ways that we hope will be useful to you in your work in implementing the new Standards. Our research team includes three people: Dr. Jacob Foster, the State science coordinator of Massachusetts, whose research background is in science education, Allison Scheff, whose graduate work was in the area of science education policy, and Hannah Sevian, a chemistry professor specializing in science education, who has also worked as a middle and high school science teacher, a district science coordinator, and in the science education policy sector in Washington, DC.

This is a design-based research study. This means that: 1) findings from the data will be shared with you during the course of your participation, and you may choose to incorporate what you learn from this into your continuing work, if you determine the feedback to be useful; and 2) your ideas on what is most relevant and valuable will shape the research as it evolves over the course of the study. You will make up an alias name to be used in data analysis, however, due to

the design-based nature of the study, all of the participants and the research team will become informed of findings from the research as it progresses, and some exposure of the aggregation and variability of participants' views will occur, though specific views will not be attributed to individuals. An important commitment in participating in a design-based research study is based on the value you deem to be associated with participation in terms of the value of the findings shared during the progress of the study.

[Text for the State Science Coordinator in focus State recruited]

We would like to include [*State*] as a focus State in the study. Your participation in the study would be the same as the State Science Coordinators in the other five States, in terms of participating in four interviews during the next three years, and providing us with information (e.g., professional development workshop agendas, instructional materials adoption scoring and analysis documents, schedules of professional development workshops anticipated, summaries of resources expected to be provided on your State Department of Education website) about the resources made available by the State for school districts, schools, administrators, and teachers, for the purpose of implementing the NGSS. In addition, we would ask you to help us in this beginning stage in thinking about three school districts in your State that are working toward implementing the NGSS and would be invited to participate in the study.

[Text for the State Science Coordinators in non-focus States]

We would like to include [*State*] as a non-focus State in the study. One of our aims is to understand how systems of resources directed at the State level are brought into coordination to support the implementation by school districts, schools, and ultimately teachers, of the NGSS. You would participate in four interviews during the next three years, and would provide us with information (e.g., professional development workshop agendas, instructional materials adoption scoring and analysis documents, schedules of professional development workshops anticipated, summaries of resources expected to be provided on your State Department of Education website) about the resources made available by the State for school districts, schools, administrators, and teachers, for the purpose of implementing the NGSS.

[Text for the District Science Coordinators in focus States]

We would like to include [*Name of School District*] in the study. One of our aims is to understand how systems of resources directed at the school district level are brought into coordination to support the implementation by school districts, schools, and ultimately teachers, of the NGSS, as well as how State-provided resources are utilized. You would participate in four interviews during the next three years, and would provide us with information (e.g., professional development workshop agendas, instructional materials adoption scoring and analysis documents, schedules of professional development workshops anticipated, summaries of resources expected to be provided on your school district website) about the resources made available by your office for teachers and administrators, for the purpose of implementing the NGSS. In addition, we would ask you to help us in this beginning stage in thinking about three teachers of science in your district who are taking a leadership role in the implementation of the NGSS. We plan to invite three teachers from your district to participate in the study, one in the K-5 grade band, one in grade 6-8 band, and one in grade 9-12 band.

[Text for the Teachers of Science in the three school districts in each focus State]

We would like to include you in the study. One of our aims is to understand how teachers play leadership roles in the implementation of the NGSS in their school districts, and particularly how resources are coordinated to support the implementation by teachers of the NGSS, as well as how district- and State-provided resources are utilized. You would participate in four interviews during the next three years, and would provide us with information (e.g., professional development workshop agendas, instructional materials adoption scoring and analysis documents, schedules of professional development workshops anticipated, summaries of resources expected to be provided to teachers at workshops and within your district) about the resources you make available for teachers and administrators, for the purpose of implementing the NGSS.

We'd be pleased to discuss any questions you may have. Thank you for considering this.

Sincerely,

Appendix B

Full interview protocol

Source, Sevian, 2012

Note for researchers to keep in mind while conducting interviews: Each set of questions is divided into three bullets, which are:

- What compels or motivates districts, schools, and/or teachers to implement the NGSS in a local-control context?
- How can and do State and district policies work in concert or in opposition to the implementation of the NGSS?
- In what ways should traditional or typical local-control roles of the State and districts change to support effective implementation of the NGSS?

State Science Coordinators

- What assumptions underlie your State's local-control policy context? How do they influence the State's approach to motivate and/or compel districts to implement new Standards?
- What are the most important policies your State has, is preparing to put into place, or could develop to help schools and districts implement the new Standards? Why are these policies so critical? What current policy(ies) do you anticipate changing to support district implementation?
- What are the traditional roles and responsibilities of the State in supporting implementation of new Standards? How will (might) that be different for implementing these new Standards? Why? What roles and responsibilities are traditionally left for districts to take on? How will (might) that be different in this implementation? Why? What sorts of resources will the State need to provide to support effective implementation of new Standards?

District Science Coordinators

- What motivates your district to implement new Standards? Why is it worth implementing new Standards in your district?
- What district-wide policies or practices have you (or are you preparing to) set in place to support implementation of the new Standards? In what ways does State policy matter critically as your district moves to implement new Standards? Are there policy(ies) that the State currently has that will be important to supporting, or obstacles to, your implementation? What policy(ies) does the State not provide that you need? How do you see your district's plans and the State policies working in concert to support implementation of the new Standards?
- What functions or roles does the district play in supporting the implementation of new Standards in your schools? How is your district, or will your district be, working differently with the State and with teachers than it has in the past on implementation (planning)? Besides policy, what resources will the district provide (or are preparing to provide) to support implementation of new Standards? Besides policy, what resources does (or will) the State provide to support implement in your district? What functions or resources should the State provide to the district (or schools or teachers) to support implementation?

Teachers of Science

- Why are you interested in the new Standards? What motivates you to implement them? Is there pressure on teachers to implement them? Where does that pressure originate and do you consider it to be positive or negative?
- Other than additional resources like supplies and books, what support and policies do you see teachers and administrators needing most in order to successfully implement the new Standards? Do you distinguish among State, district, and school level policies? How do you see each? Which of the needed supports you outlined can or are being provided

by the State and which by your district and your school?

- What are your responsibilities in implementing new Standards at your school? In what ways does (or will) your district support your implementation of new Standards? In what ways does (or will) the State support your implementation of new Standards? Which supports do you anticipate will be (are) most helpful and why? What won't work (isn't working) and why? Do you see new or different roles for the district or State in this implementation that need to be different from past standards implementations? Are their functions or resources your district or State should provide to teachers to support implementation?

Appendix C

Outline of all primary and secondary codes

	Primary Codes	Secondary Codes	Description	Examples
1	Challenges of implementation		These set of codes are focused on the challenging aspects of the adoption/implementation process at a given level	
2		Chal: Collaboration	Challenges related to collaboration between the levels or within levels	One of the things that we're striving to do, that we'd like to do is to have a little bit more collaboration across the grade levels. At this point we're still kind of K-5, 6-8 and 9-12. And we don't always collaborate as much as we should and sometimes we hurt a little bit with those transitions. But, we certainly have that in place as a district initiative too. (B3-DC)
3		Chal: Creating a coherent system	Challenges related to making the system coherent	"Because it's important to present an aligned system, in the sense that all of the various components need to work together and send the same message. If that doesn't happen, then districts are confused and/or they don't have the time to straighten it all out, figure it all out, so they'll either make their own interpretations or they'll do little until it gets figured out."(A-SC)
4		Chal: Standards fatigue	The NGSS are too much of a change, place too much burden, or seen as detractor from motivation.	"I mentioned the shifting legislative climate, you know, that changes, the standards that we have. There's some kind of changes every single year and that is so detrimental. "(B3-ES)

5		Chal: Differences between current and new standards	The NGSS are too different, and therefore missaliged, to current state statdards.	So I definitely know…we took the last [state]…what do you call them, the [high school standards]. We took those from the state. [Regional service agency] then kind of gleaned out some big ideas and then as a district we sat down in small groups, went through those big ideas and said "Hey, this is what we think is important to teach." So I definitely think that there's input from each level, but this sounds like a much bigger change than we witnessed in the past. We went from a curriculum framework to right now the current content standards, and that was a shift but along the same content-driven philosophy. This is a fundamental shift of how we're going to deliver content. So I think it's a bigger change. So I'm not sure how that's going to play out at each level."(B2-HS)
6		Chal: Lack of stakeholder leadership for STEM	Not enough leadership to support the new standards	"I think that you need to have more administrators…I don't want to say science literate…I do want to say science literate. We have a lot of wonderful administrators in my building, and they're fantastic. But if you don't have a basic understanding of what science looks like, and what a good science classroom looks like, I'm not quite sure how they're going to assess it. Or I'm not quite sure how they're going to say it's successful. They're relying on a few teachers to say what do you think about this and this and that's great, but I think that more administrators need to be comfortable in a science setting, and they need to be able to go in and see this is what inquiry looks like; this is what investigations look like; this is what the science teacher is trying to achieve, because it's very different than other subject areas in that sense. And I think it's hard to gauge what a good science classroom looks like unless you have some basic things to look for. What should we be seeing in here?"(B2-HS)

7		Chal: Obtaining buy in from field	Challenges related to others accptence of the NGSS within the field of science education	"So trying to get the…cause, you know some people come in the room and they're excited but then they start thinking about the hugeness of it and get really kind of negative. And so part of it is to walk that fine line of reality and excitement."(A1-DC)
8		Chal: Boundaries of local-control states	Challenges of implementing the NGSS in a local contol state	"There are certainly tensions around the state and district relationship. The state Department of Ed is traditionally not seen as a resource, in part because we've never played that curriculum role."(A-SC)
9		Chal: Development of state assessment	Challenges related to state assessment(s)	"we are going to need to have assessments in place that measure these standards at their fullest for folks to move forward. Not necessarily because that's an essential component, but because we've taught people that the assessment is the most important thing. And we've taught people that the summative assessment is the most important thing in the last 10 years. And so they're going to need that as almost a support to move forward."(D-SC)
10		Chal: Consolidating scattered resources	Challenges related to finding recources, or figuring out what resources are available and making them accessible	"I would like to see the state more involved in connecting resources. Our state department really isn't involved in that…connecting, you know, and building that infrastructure."(B3-ES)
11		Chal: Teacher change	The ability of teachers to implement the NGSS, elementary school teacher's comfort with science content, a shift in teacher pedagogy, and teachers familiarity with content and practices	"I think that there's a ton of PD about it. Because otherwise people are just going to freak out. (laughing) You know, they really are…they're very, very dense. And there's a lot of moving parts. And I feel like it could really be something that feels like it's scary and overwhelming. And how can you do one more thing? "(A1-MS)
12		Chal: Developing and making available appropriate resources	Achieving consensus on what resources are needed, adopting resources, the usefulness of resources, and the influence of prior curriculum/assessment/professional development materials.	"a big need is going to be professional development time because teachers are going to need to work on this to get things modified, and that costs money" (A2-DC).

13		Chal: Adjusting state policies	Challenges related to changes that might be needed to state policies in order to adopt or implement the NGSS	"Teacher certification would be impacted. So, what does that look like? Who's qualified to teach these courses? Are teachers gonna need to have… engineering cross training or an engineering education endorsement? You know, there's these kinds of things. So, I would say policies around teacher certification. Policies around graduation. Those things definitely could create issues" (B1-DC)
14		Chal: Value placed on science Ed	Education policy or schools/districts prioritizing ELA and math over science, public perception that science matters less than other subjects, this may include AYP or accountability in other subject areas	"I don't know how they can stress science and make people…really buy into…these new standards. Because of the other poles in the…in the…big two. I mean reading and math. I don't know the answer."(B1-ES)
15	Factors effecting change		These set of codes are focused on why things happen at each level and the sources of pressure or incentives for individuals or organizations to change. Why do they want to change, or why do they feel they have to change?	
16		Fact: Assessments	Positive or negative ways that assessments drives decision-making and action	"We're driven by the state test, which in our case is the [title] test."
17		Fact: Change as an opportunity or empowerment	Change as opportunity to engage field, to empower leadership or intellectual engagement of teachers, etc.	"it makes things a little bit unsettled, and makes that ground fertile for having potential change conversations and moving forward"(D-SC)
18		Fact: Funding linked to implementation	Implementation of new standards as a condition for awarding of funds	"They will have more PD. They already have them. They've already started them. And, I do believe they are reasonably priced. But they don't have grants to pay for it. They will have reasonably priced PD available that will be high quality."(B1-HS)
19		Fact: New or modified legislation	Legislation to change graduation requirements or the order or scope of science courses (e.g., teaching bio in 9th grade and chem in 10th grade, or adding an Earth Science course)	"State policy sets what we actually have to teach to, so they set the standards, so whatever that is, that's the first driver."(A1-DC)
20		Fact: Professional development	Common interest for PD or recognition of the need for new or additional PD	"I think the support is gonna have to come from the district providing professional development um and what limited people that they can to send out and either model teaching or work with teachers. You know, to, to implement the standards."(B1-MS)

21		Fact: Science literacy	Seen as an opportunity to acieve science literacy for all students.	"But that I want to be looking and be very forward thinking. Like, where is science today? What do they need to know today to be both a science literate member of society as well as if they want to pursue science in the future. What they need to know and be able to do. So I'm very motivated that sort of a new set of standards; what's new; what's current; what's expected of everybody around the country so that I can help prepare my students to be competitive or to be able to live healthy, successful lives, whatever they do in society."(A1-HS)
22		Fact: Aligned with or supports current efforts	NGSS implementation aligns with the Common Core State Standards or other current science efforts	"The main message was that it represents the kind of changes that we as a state are moving to, whether or not we adopt NGSS. That includes things like integrating practices with content."(A-SC)
23		Fact: Licensure	Change in teacher licensure requirements (e.g., adding an engineering teaching certificate)	"So, regardless of what happens, we will have changes that we need to make in all aspects of the teacher certification, so the testing, what are we asking the prep universities to do? All of that will have to be adjusted, but I'm personally not aware of the timeline on which that work will be done."(B-SC)
24		Fact: Availability of resources aligned to standards	When there is a need for the resources, people will go to what is aligned; the message will be delivered with them; resources could include sample curricula, PD, model units	"trying to motivate and encourage districts to implement the standards in ways that we feel are appropriate. And we do that by providing as much resources as we can. That includes, for example, some sample curricula, professional development to help teachers understand the new standards"(A-SC)
25		Fact: Realization of common values, desires, hopes	Motivating around common values, such as shared goals, prep for business/industry, appreciation of rigor of the new standards	"I want my kids to be ready. I want them to be competitive. And the new standards, the Next Generation Science Standards is very important for us to move towards this. We're linking from grade level to grade level and infusing inquiry standards, and really preparing them for a life and society that needs engineers and scientists who can think, can really think and problem solve. And I want my kids to be ready for that."(B1-HS)

26	Policies		These set of codes are focused policies that are currently in place or policies that would need to be considered to make the NGSS implementation successful	
27		Pol: Licensure	Teacher licensure policies	"And then licensure. That is one where the policy would change, we'd still maintain the license, but we have to adjust the licenses slightly to reflect the new expectations for teachers. The expectations for teacher licensure are functionally a mirror of the expectations that we have for kids, so it's a way of assuring that the teachers know something about what they're supposed to be teaching."(A-SC)
28		Pol: Legislative implications for curriculum decisions	Who makes decisions about curriculum, and how might this impact the NGSS?	"And actually I think to some extent, at least in the past it has been somewhat legislatively expected in our [Year] education reform law that created standards, it came with an expectation that we provide enough resources to help implement the standards. That was true in the past, that we'd maintain that kind of expectation for any future standards, but I'm not sure that we have that kind of legislative mandate anymore." (A-SC)
29		Pol: Educator Evaluation	Policies around teacher accountability measures	"We now have teacher evaluations that need to be done annually for every teacher. So that policy which has just been changed within the last year in our state has definitely upped the stakes for all teachers. Fifty percent of their evaluation is now based on student achievement growth, so obviously that plays into it."(B3-DC)
30		Pol: Assessment and Accountability	Policies around student accountability measures; can present as "mandate" seen by teachers as coming from district or state	"And the reason I say that is because our kids our held accountable for high stakes tests for graduation. And so I can't just do what I want and I can't just promote what I want or what I value. But I have to promote whatever the state values because that's what kids are held accountable for"(A1-DC)
31	Implementation strategies		This section is focused on how implementation of new standards is to be accomplished.	

32		Strat: Advocate for new/changed legislation	Advocating for new legislation	"if the NGSS are adopted by the state of [state], then the district would create a formal policy of adoption go the Next Generation Science Standards for the district. "(B1-DC)
33		Strat: Consistent messaging across levels	Coherence and synergy across levels, raise awareness of vision of the new standards	"we try to also have these trainers available to go out and work with districts, and make sure that they have some of the same messaging that we do so that we try to be consistent even if it's different people across the state. "(D-SC)
34		Strat: Create aligned assessments	Creation of new assessments aligned to the NGSS	"And actually that's kind of a common strategy among many of the challenges that we have. We have something called assessment development committees, which include teachers, or are made up of teachers, and they help us review state assessment items for alignment to standards, for reasonability, for bias, those kind of things."(A-SC)
35		Strat: Engage resources for change from outside organizations	Cooperate and coordinate with other organizations, e.g., professional societies	"I believe we will be looking for partnerships with universities, with non-profits, with businesses to help make the standards real. And so it may mean things like internships or visits or…just different kinds of collaborations that all would be coordinated through the district."(B1-DC)
36		Strat: Foster collaboration across districts	Collaboration between districts	"you can have the same potential to work with districts if you can get folks to opt in to working together, then it's not me telling somebody that this is the curriculum that you have to do and you have to do it in this way, but getting people to opt into collaboration, I think helps us move forward in a better way than controlling, trying to control what happens in the classroom."(D-SC)
37		Strat: Learn from Common Core rollout	Lessons learned from the Common Core State Standards implementation process so that it can be built upon with NGSS rollout	"I've also been a part of our Common Core implementation team, and so we've learned some things from that, in that of course it takes ongoing professional development, not just a little snippet, in order to move forward."(D-SC)
38		Strat: Learn from successful districts and schools	Sharing what works from one school or district to another	"take the go-getter, more advanced districts that are what we call the thoroughbreds, and watch carefully what they're doing."(C-SC)

39		Strat: Learn what stakeholders' issues are so an agenda can be developed	Stakeholders include, for example, principals, superintendents, boards of education, PTA, teachers unions	"a review team of about 60 people that is K-12 educators, postsecondary educators, both educators of teachers and science professors as well, and folks from business and industry, that we've been bringing together around this review."(D-SC)
40		Strat: Provide PD to support implementation	New or additional PD to support implementation	"I think there should be professional development from the district for teachers and for building administrators. And I think the state is also going to need to run some professional development, whether it's through district leaders or also to reach out to teachers. I'm not sure."(A1-HS)
41		Strat: Strategically use available funding	Federal or State DoE funds such as grants to do specific aspects of NGSS implementation support	"I believe we would look at providing resources through our Title I dollars and other resources for equipment and materials to help support the implementation."(B1-DC)
42		Strat: Create/organize resources	State and districts providing new curriculum resources (e.g., textbooks or curriculum)	" the biggest difference will be around curriculum resources and trying to coordinate resources that exist out in the field, we've never done that before."(A-SC)
43	Advocate		Has the interviewee advocated for or against the NGSS?	
44		Adv: Advocating for	Advocating for the NGSS or aspects of the standards that are different from the current state standards	"I would probably talk to the other teacher leader that identifies in the building and see, kind of…what she thinks about the idea…you know, how can we get the other half of us really kind of invested and up to speed? And I would begin talking to them. I would begin talking to them and say, 'Do you know about the Next Generation Science Standards? And how do you feel about them? And what do you…you know, I know about them and I like them, and what can I do to help you?' And how's the best way to go with that and try to honestly figure out a way for them to kind of take a lead in directing how to support them in…the implementation phase. You know…um…our principal is very much in support of science education and is also very much in support of sort of this integrated approach to education. And so he is quite happy to support science across the curriculum."(A1-MS)

45		Adv: Not advocating for	Not advocating for the NGSS or aspects of the standards that are different from the current state standards	"I feel that the district does a nice job of providing the support. I'm actually…have to do…told what I'm to, you know, present to the teachers and such with implementation. I take it, and take it on and give it to my teachers. I think the district really supports it as much as the budget allows."(B2-DC)
46		Adv: Advocating against	Advocating against the NGSS or aspects of the standards that are different from the current state standards	"I think what we have right now is actually very good and we shouldn't fix things that aren't broken. I think that the…(pause)…I think very…I think right now part of the thing that really stinks about being a teacher is just that there are more and more and more of these"(A1-MS)
47	Motivation		Aspects of the standards or the interviewees personal perspective that motivates them to consider implementing the NGSS	
48		Motiv: Reasons motivated for	Stated reasons motivated for implementation	"So, it's huge. It's huge in a climate that doesn't…doesn't seem to be aware of the fact that science has to be a core part of what children experience every day in school"
49		Motiv: Reasons not motivated for	Stated reasons not motivated for implementation	And then just the resistance to change. I have teachers that are amazing and they've been doing this for 30, 35 years, and I'll tell you what, they're a pretty sure they know how to teach physics or chemistry or whatever their subject matter might be. And for me to come in and say now you have to leave things out that you've taught forever and you think are so important, it's going to be…it'll be a huge challenge." (B2-DC)
50		Motiv: Reasons motivated against	Stated reasons motivated against implementation	"And the only thing I'm afraid of, or concerned about…the things that make me nervous about it is that it's going to take a lot of work and a lot of energy and I'm always asked to do everything…I'm always asked to do an awful lot [by the upper administration] that is not at the core of what I should be doing... in the sense that there will just be competing agendas that I will have to align with. And so that's a great concern for me. Another tension…is to have the time to do the work that I know needs to be done." (A1-DC)

51	Epistemology		The extent to which an awareness of how science knowledge is constructed influences their consideration of the NGSS	
52		Epist: Referenced epistemology	Referenced science epistemology in the NGSS	"I absolutely come from a mindset or curriculum theory that's based on inquiry based, hands-on, crosscutting concepts, implementing the practices into actual instruction."
53		Epist: Used science epistemology	Used specific aspects of the science practices of the NGSS as a reason for liking/disliking the NGSS	"Maybe working more on, you know, claims and evidence, or different…like kind of pictures what it would look like in the classroom I guess, you know. Just kind of modeling it."
54	Components of the NGSS		Comments on the elements of the NGSS that come from NRC Framework or one of the NGSS drafts of the standards	
55		NGSS: Career- & college-readiness	Interviewee references aspects related to college- and career-readiness	"My personal take on it is that it is certainly more the direction we want our kids to be going in. I think that the rigor, and probably even the relevance for these kids going forward, you know, if we're going to get them college and career ready, I really think this was a good choice."(B3-DC)
56		NGSS: Crosscutting concepts	Interviewee references aspects related to inclusion of crosscutting concepts	"And then, you have a different view. You start to think about things in terms of…sort of the bigger themes of science. So like the crosscutting concepts, you know, for example in our framework. When I talk to the teachers who have PhDs and we talk about those, that makes sense to them and they put up signs around their rooms, you know, of those, to refer to as they're teaching."(A2-DC)
57		NGSS: Engineering	Interviewee references aspects related to inclusion of engineering with science	"But I think it's a very good way these engineering practices have been developed."(B2-HS).
58		NGSS: Progressions	Interviewee references aspects related to progressions of learning across grade spans	"standards are very useful for a variety of different reasons. It helps us to have good K-12 align…vertical alignment"(A2-DC)
59		NGSS: Practice-content	Interviewee references aspects related to integration of practice and content in standards	"of course we want the best quality of education for our students, and practices and content that, you know, are cutting edge in keeping with what the recommendation is looking at. "(B3-ES)

60	Possible Misconceptions of the NGSS		Apparent misconceptions about what the NGSS are, or how they are intended to effect science education at the state, district, or school/teacher level.	"And again, I haven't really–I haven't seen the exact specifics of the Next Generation Science Standards. I don't know–is that the same things as common core?"(B3-HS)
61	Informative quotes		Good quotes that I wanted call out from the interviews.	"They could give you at least some guidance and give someone like me some ammunition to fall back on when I try to say that's not optimal. But they don't give you anything except what they want the outcome to be." (A2-DC)