THE NEXT GENERATION SCIENCE STANDARDS: UNDERSTANDING HIGH SCHOOL TEACHERS’ PERSPECTIVES ON IMPLEMENTATION

By

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To the Faculty of Washington State University:

The members of the Committee appointed to examine the dissertation of PATRICK MORRIS DAISLEY find it satisfactory and recommend that it be accepted.

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I would like to thank the many people who have walked with me during the past five years on this journey. Your contributions and ideas, love, patience, support and encouragement have enabled me to continue; even when I was sure I could not.

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THE NEXT GENERATION SCIENCE STANDARDS: UNDERSTANDING HIGH SCHOOL TEACHERS’ PERSPECTIVES ON IMPLEMENTATION.

Abstract

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The purpose of this qualitative interview study was to explore the challenges faced by Washington State high school science teachers in regard to implementing the Next Generation Science Standards (NGSS) in their classrooms. The study addressed and attempted to answer the following three research questions: (a) How are the Next Generation Science Standards (NGSS) impacting high school science teachers’ approaches to classroom teaching? (b) What are the challenges that high school science teachers are facing in attempting to use and implement the Next Generation Science Standards (NGSS) in their teaching? (c) What resources do high schools science teachers need to effectively implement the Next Generation Science Standards (NGSS) in their classroom teaching? Seven high school science teachers from eastern Washington State were interviewed to gain their perspectives on the challenges they face in their efforts to implement the NGSS. Four major themes emerged from the data analysis: (a) impediments to implementation, (b) the contextual nature of implementation, (c) impact of implementation on teachers, and (d) needed supports for implementation. The following four conclusions of this study can be stated: (a) The Next Generation Science Standards (NGSS) is a complex reform policy for science education that are difficult for science teachers to understand and implement, (b) there are multiple impediments to full implementation of the NGSS that need
to be addressed, (c) substantial professional development is needed to help administrators and teachers understand the NGSS and to learn new methods to employ in science classrooms, and (d) school and district administrative support is needed to provide the resources and help create a culture that values the efforts of teachers in meeting the challenges they face implementing the NGSS.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>AKNOWLEDGEMENTS</strong></td>
<td>iii</td>
</tr>
<tr>
<td></td>
<td><strong>ABSTRACT</strong></td>
<td>iv</td>
</tr>
<tr>
<td></td>
<td><strong>DEDICATION</strong></td>
<td>ix</td>
</tr>
<tr>
<td>1.</td>
<td><strong>INTRODUCTION</strong></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Background</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Purpose</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Research methods</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Research Ethics</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Personal and Professional Standpoint</td>
<td>10</td>
</tr>
<tr>
<td>2.</td>
<td><strong>LITERATURE REVIEW</strong></td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Introduction</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>STEM Education</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Science Standards</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Next Generation Science Standards</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Washington State Science Education</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Issues Surrounding Implementation of Education Standards</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Teacher Understanding and Perspective of Standards</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Summary</td>
<td>23</td>
</tr>
<tr>
<td>3.</td>
<td><strong>METHODS</strong></td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Introduction</td>
<td>25</td>
</tr>
</tbody>
</table>
Implications of this Study................................................................. 62
Reflections .................................................................................. 64
BIBLIOGRAPHY ........................................................................... 67
APPENDIX A: Interview protocol...................................................... 73
Dedication

This dissertation is dedicated to my wife Lori.

You made everything I have achieved in this life possible.
CHAPTER ONE

INTRODUCTION

This is a qualitative interview study that explores high school science teacher’s understandings and interpretations of the Next Generation Science Standards (NGSS), which were recently adopted by Washington State, as well as their perspectives on implementing the standards in their classroom instruction.

While improving science, technology, engineering, and math (STEM) education has received much attention in recent literature, there is a lack of research on how newly adopted science standards are impacting these improvement efforts. Since classroom science teachers are the key players in improving STEM education and implementing the new standards, it is important to understand their interpretations of the NGSS and perspectives on the challenges involved in adapting their curricula and teaching practices to address the new standards. With this understanding, educational leaders and policy makers may better provide support to science teachers as they address implementation issues.

Background

To help meet future employment demands and keep the United States competitive in an increasingly technological world market, governments and businesses promote science, technology, engineering, and mathematics (STEM) efforts in education. In regard to Washington State, Carnevale and Smith (2012) estimated that in five years, 67% of the jobs in the state will require some form of higher education beyond high school and that many of these jobs will be in healthcare and STEM occupations. The Washington Research Council (2011) reports that between 2001 and 2011, 11.5% of new jobs in the State of Washington were STEM related. However, international tests of mathematics and science achievement rank American students
below many of the other first-world industrial nations in mathematics and science achievement (Martin, Mullis, Foy, & Stanco, 2012), and there is an increasing emphasis on improvement of science teaching and learning.

Development of new learning “standards” within specific curricular areas is one approach to improving education. In 1983, the National Commission on Excellence in Education released the report “A Nation at Risk” (Gardner, 1983), which called for higher standards for education. Subsequently, professional organizations, such as the National Council of Teachers of Mathematics (NCTM), started developing educational standards, which then began to be adopted by states. The No Child Left Behind Act of 2002 further emphasized standards in requiring that states administer science tests to students in elementary, middle and high school (US Department of Education, 2010), and that these tests be based on state science standards. According to Ravitch (1995), such standards are useful tools for guiding teachers and students as to what they should teach and learn. Over the years, however, standards have changed and evolved.

The most current standards for science are the Next Generation Science Standards (NGSS), which were developed through a process that began in 2010. The National Research Council (NRC), working with The American Association for the Advancement of Science (AAAS) and the National Science Teachers Association (NSTA), published A Framework for K-12 Science Education, which was finalized in 2011 (NRC, 2012). The framework describes a vision for science education that focuses on a smaller set of core ideas and includes increased emphasis on practices and connections between subject areas. This framework provided the basis for the development of the Next Generation Science Standards (NGSS). Achieve, Inc., facilitated the development of the NGSS. The work was conducted primarily by the NRC, AAAS, NSTA, and 26 lead states, one of which was Washington. The standards were completed
and released in April of 2013 (Achieve, 2014) and were adopted by the State of Washington as the “Washington State 2013 K-12 Science Learning Standards.” For simplicity sake, in this study I will continue to use the term Next Generation Science Standards (NGSS) for the adopted science standards in Washington.

Given the complexity of the Next Generation Science Standards (NGSS), there is the possibility that some science teachers may not fully understand their intent. The NGSS’s added focus on the practices of scientists and engineers (SEPs) and crosscutting concepts (CCs) represent a new emphasis on “how knowledge and practice must be intertwined in designing learning experiences in K-12 science education” (NRC, 2012). There is a risk that this new “vision for education in the sciences and engineering” (NRC, 2012, p.8) will not be achieved if science teachers fail to grasp their goals.

Educators throughout Washington State now have the task of implementing the new science standards. Implementing any new policy brings with it challenges, which, if not considered, can adversely affect the success of the effort (Fowler, 2009; Spillane & Callahan, 2000; Spillane, Reiser, & Reimer, 2002). When policies relate to curriculum and instruction, teachers are at the heart of successful implementation. Teachers are policy implementers (Fowler, 2009); their understanding, vision, and interpretation greatly affect the degree to which new policies are implemented in their classrooms (Spillane & Callahan, 2000; Spillane, et al., 2002). Gross, Giacquinta, and Bernstein (1971, as cited in Fowler, 2009) found obstacles that hampered implementation of educational policy, including that teachers did not really understand the change that the policy called for, and, when the policy called for pedagogical change, teachers did not know what to do. Teachers, like all people, come to understand new ideas in light of their current experiences and beliefs (Spillane, & Callahan, 2000). The NGSS offers a
new vision for the teaching and learning of science; if teachers fail to understand how the NGSS standards differ from earlier sets of science standards, efforts to successfully integrate them will likely fail (Fowler, 2009).

Currently there is a dearth of research on the challenges teachers face when adapting their practice to incorporate new educational standards, including the Next Generation Science Standards (NGSS), recently adopted by Washington State. Since science teachers are the instruments for successful implementation of the NGSS, understanding how they view and comprehend the standards and the challenges they face in implementing them in the classroom is crucial to providing appropriate support and resources for successful implementation.

**Purpose**

Given the lack of research on the challenges teachers encounter in implementing new science standards, the purpose of this qualitative study is to explore the challenges faced by Washington State high school science teachers in regard to implementing the Next Generation Science Standards (NGSS) in their classrooms. In order to accomplish this I will attempt to answer the following three research questions: (a) How are the Next Generation Science Standards (NGSS) impacting high school science teachers’ approaches to classroom teaching? (b) What are the challenges that high school science teachers are facing in attempting to use and implement the Next Generation Science Standards (NGSS) in their teaching? (c) What resources do high schools science teachers need to effectively implement the Next Generation Science Standards (NGSS) in their classroom teaching?

**Research Methods**

This is a qualitative interview study that employed phenomenologically oriented methods for conducting interviews, as described by Seidman (2013) and Merriam (2009). A
phenomenological approach was appropriate for this study because I sought to gain an understanding of the experiences and understanding of high school science teachers in regard to implementing the NGSS, as reported in their own words. As Seidman (2013) states, “In-depth interviewing’s strength is that through it we can come to understand the details of people’s experience from their point of view” (pp. 143-144).

In-depth, open-ended interviews were conducted to explore the “lived experiences” (Seidman, 2013, p. 17) of high school science teachers in Washington State as they relate to their understanding and interpretation of the Next Generation Science Standards (NGSS) and their efforts to implement them. Seven high school science teachers were selected from three districts in eastern Washington as participants in the study. The selected school districts were typical of the region and easily accessible geographically, and provided a sufficient number of science teachers from which to select participants. I limited the study to high school science teachers because high school students must pass the standards-based, state science assessment mandated as a graduation requirement. Therefore, high school teachers would seemingly have the greatest incentive to attend to implementation of the standards. The costs for data collection and analysis, both monetary and time related, were factors in limiting the number of participants.

A single in-depth interview was conducted with each participant to gain an understanding of his or her individual perspectives on the NGSS. (See Appendix A for the interview protocol.) Analysis of the qualitative data was guided by the phenomenological techniques presented by Seidman (2013). A more detailed discussion of the research methods is included in chapter three.
Research Ethics

Qualitative interview studies do not generally present a high degree of risk for participants, but researchers must nonetheless work to eliminate or mitigate those risks. The kinds of risk participants face depend upon their particular circumstances.

Seidman (2013) identifies ethical concerns around openness and honesty with participants and their treatment as worthy individuals. Participants should be fully informed about the purpose of the research and the benefits and risks participation may bring. They should be able to freely make informed decisions about participation without pressure. Researchers should take seriously their commitment to informed consent, taking time to fully discuss with participants what participation means, including potential risks and benefits. Promises must not be made which the researcher cannot deliver. These could include potential monetary benefits that may derive from the research or knowledge gained.

The conduct of the interviews themselves presents potential risks. When attempting to understand participant’s experiences and meaning Seidman (2013) encourages researchers to “treat interviewing as an exploration, not an attempt to prove something they have in mind” (p. 141). Asking leading questions inhibits participant’s freedom to answer questions in whatever way they choose. Interviews should not be treated as if they are interrogations. Questions may surface painful memories or uncomfortable situations that participants may be reluctant to relive. Researchers can show respect for their participants by listening attentively and allowing them to share as much or as little as they choose. Seidman emphasizes that researchers’ primary responsibility is to their participants. Researchers show respect and preserve the dignity of their participants by endeavoring to be “worthy witnesses” (Winn, 2011, as cited in Seidman, 2013, p. 144) of their stories and experiences.
Researchers own sense of ethics and values form the basis for ethical practice, according to Merriam (2009). The ways researchers negotiate the situational ethical issues that arise during research depend on their values. When analyzing data, the meaning researchers make from it is filtered by their own biases. Deciding what is important, and what is not, is the researchers’ prerogative. This opens the door to misrepresenting the intended meaning of the participant or excluding something they felt was important.

Merriam (2009) also shares some of the more common concerns about potential harm that can come to participants. Participant’s may feel embarrassed by some of the questions or feel that their privacy is being invaded. If participants are at ease with the researcher there is a risk that they may reveal things they are not comfortable with or more than they intended. Protecting the anonymity of participants can also pose challenges especially in situations where participants represent a unique case. Merriam says that locally “it is nearly impossible to protect the identity of … the people involved” (p. 233).

Rubin and Rubin (2012) echo most of the concerns presented by others (Seidman, 2013; Merriam, 2009). They organize risks around respect for participants and not harming them. Wasting participant’s time is disrespectful. This means being on time for scheduled interviews and ending when promised. Asking questions for which the answer can easily be found from other sources is also wasting participant’s time. Participants should be asked for permission to record the audio of the interview. Researchers should always be polite, especially if a situation is tense. Being polite includes allowing participants to answer questions and tell their stories in their own time, without interruption. Participants should not be pressured to participate or to answer questions about which they are hesitant.
Participating in a study should not harm participants. Protection from harm includes keeping promises to participants, especially those around confidentiality, and giving them warning when it may not be possible to keep such promises, as may be the case if the researcher uncovers unethical or illegal activity. Rubin and Rubin (2012) emphasize that ownership of the data collected during an interview resides with the participant, not the researcher. Participants have the right to deny its use, in whole or in part. Permission should be sought to quote participants and researchers should respect participant’s requests to not quote them. In the end, Rubin and Rubin point out “your first ethical obligation is to your interviewees, to do them no harm and to keep promises you have made” (p. 89). Participants should not suffer because they participated in a study and researchers should seek ways to avoid harming them.

Informed consent provides the foundation for limiting potential harm to participants (Seidman, 2013). Participants deserve and are entitled to as much information as possible in order to understand the potential risks and benefits of being part of the study, so that they may make an informed choice about participating. They are in the best position to judge their risks, but must have full knowledge of the study.

This study is fairly typical in terms of the risks involved for a qualitative interview study that does not focus on sensitive or overly personal topics. The content of the interview questions were unlikely to cause embarrassment or discomfort. When discussing the science standards, teachers may feel as if they represent an ideal for teaching. This could give rise to feelings of inadequacy if they feel like they are not sufficiently addressing them. To alleviate this I emphasized, both before and during the interviews, that I am not trying to ascertain how well they comply with the standards, just what their views and experiences with them have been.
Certainly it is possible that the opinions held by some of the teachers ran contrary to the official views of their districts or principals. Participants may have chosen not to share their opinions openly within their work settings and may have feared that being identified and associated with their opinions could result in harm. Care was taken to preserve confidentiality of their identities and schools settings so that the comments they made cannot easily be traced to them. As Merriam (2009) points out, it is sometimes difficult to do this at the local level. Despite drawing participants from teachers in the Spokane area only, this risk was reduced by the size of the potential participant pool. There are 11 school districts with 17 high schools within the vicinity of Spokane. My study drew participants from three of those districts, which collectively have nine high schools and about 100 science teachers. Pseudonyms are used for all district and school names. Demographic information about the schools and districts is discussed separately from that of the teachers. These precautions reduce the risk that any individual teacher will be easily recognized. Transcripts of the audio recordings of the individual interviews were shared with individual participants, if they desired, respectively, but only of their own interviews.

In this study, the informed consent form included a description of the purpose and methodology of the study and detailed the potential risks and the measures taken to mitigate them. Steps to protect participant confidentiality, as described earlier, were explained before the interview was conducted. A brief description was included detailing what participation entails (a single, audio recorded interview lasting up to 90 minutes), how data will be analyzed, and how it will be used (e.g., this doctoral dissertation). Statements were included that told participants they have the right to withdraw from the study without penalty or prejudice, that they had the right to review their interview transcripts to ensure accuracy and provide additional comment, and that
they had the right not to be quoted, and to redact portions of the interview they did not want included in the study. In agreement with Seidman (2013), I think it was important to take time to discuss the informed consent form with my participants, to make sure they fully understood it and had the opportunity to ask questions and for clarifications.

Accurately and honestly analyzing and presenting the data collected during interviews is also important to avoid harm to participants. To this end, I offered to share individual transcribed interviews with respective participants as well as my initial analysis. Participants may provide feedback, additional comments, and needed corrections. This “member checking” procedure (Merriam, 2009; Seidman, 2013) adds to the trustworthiness of a study, which in turn helps avoid the harm to participants in regards to being misquoted or having their meaning distorted. Three of the teachers who participated in this study wanted and received a written copy of their interview transcript; none of them returned any comments. The remaining four did not express any interest in receiving a written copy of their interview transcript when asked.

There was a potential benefit to the participants in this study. Reviewing and closely examining answers to questions can help participants reflect on their practice as science teachers. In addition, participating in qualitative interviews can be an enjoyable process for some participants (Merriam 2009).

**Personal and Professional Standpoint**

My interest and perspective on how science standards influence teaching and learning are rooted in my 20 years of experiences as a high school physics and science teacher. Because of the early influences of people like Arnold Arons, a professor of physics at the University of Washington and author of the book “Teaching Introductory Physics” (1997), and Jim Minstrell, a high school physics teacher and educational researcher, I don’t feel that I was ever a “traditional”
science teacher, like the ones I experienced in my own education. Since the beginning of my teaching career I have been interested in exploring and understanding the processes by which my students come to understand science, and the misconceptions they have about scientific concepts. I found that engaging in a Socratic-style dialogue with my students helped make their thinking clearer to themselves and to me and led to student’s understandings that were more consistent with reality.

These experiences and my interests led me to attend my first “Modeling Leadership Workshop” (Hestenes, 1997) in July of 1998 after completing my fourth year of teaching physics. Modeling instruction involves students creating conceptual scientific models as the basis of their scientific learning (Jackson, Dukerich, & Hestenes, 2008). This approach leads to a coherent base of scientific knowledge, focusing on the underlying structures that explain many of the processes in nature, and helps avoid a fragmented, surface view of scientific concepts. Student interaction and collaboration are integral components of modeling instruction. Socratic questioning techniques are used to guide student thinking, leading them to create and develop their understanding of concepts and processes.

Modeling helped shape my theoretical and philosophical perspectives on teaching science. My vantage point is in many ways consistent with that of social constructivism, where learning is considered a social process. Vygotsky (1978) describes that learning takes place when children are interacting with each other under the guidance of their teacher. I try to create an environment in my classroom where students work together making sense of new concepts and information, with my role being supportive and not the main conduit for knowledge. Success varies, of course, but my view is that teachers should strive to create these situations and not simply disseminate and manage the flow of information through lecture and demonstration.
For me, the Next Generation Science Standards (NGSS) represent a step in the right direction for science teaching. The NGSS add the dimensions of the crosscutting concepts (CCCs) and science and engineering practices (SEPs). These are very complimentary to the tenets of modeling. Policy studies have shown that understanding the details of a new policy and what needs to be done by implementers is necessary for successful implementation (Gross, Giacquinta, and Bernstein, 1971, as cited in Fowler, 2009). Therefore, my concern is that educational leaders and science teachers may not understand the changes in science teaching that the NGSS are trying to promote. Talking with them to develop an understanding of their comprehension of the standards seems like a good starting point in helping to improve science education through the NGSS. Conducting this study also contributed to my practice as a science teacher.
CHAPTER TWO

REVIEW OF LITERATURE

Introduction

This literature review is intended to frame the research problem addressed by this study, that is, understanding high school science teachers’ knowledge and implementation efforts in regard to the Next Generation Science Standards (NGSS) (National Research Council, 2013). The review includes selected literature related to (a) science, technology, engineering, and math (STEM) education; (b) science education standards in the United States and the State of Washington; (c) the Next Generation Science Standards (NGSS); (d) challenges associated with implementation of standards; and (e) teacher perspectives on educational standards.

STEM Education

Society faces many critical problems and issues, such as the spread of disease, the consequences of global climate change, and finding sustainable energy sources, that require scientific solutions (Spellman & Price-Bayer, 2010). How society deals with these problems depends on how effectively science and technology are used (Rutherford & Ahlgren, 1991). In addition, globalization has brought new economic challenges, as workers in the United States must now compete for scientific and technical jobs with workers from other countries (Committee on Prospering in the Global Economy of the 21st Century, 2005). As the Committee on Prospering in the Global Economy of the 21st Century state in Rising Above the Gathering Storm (2005) “The science and technology research community and the industries that rely on that research are critical to the quality of life in the United States” (p. 67). At the same time as the need for scientifically and technologically literate citizens grows, there is concern that schools are not adequately preparing students in the science, technology, engineering, and math

Given these multiple concerns, there has been an increasing emphasis in improving “science, technology, engineering, and mathematics” (STEM) education in recent years (Kuenzi, 2008). The acronym STEM was first used by the National Science Foundation (NSF) in the 1990’s, but it’s meaning was often not well understood (Breiner, Johnson, Harkness, & Koehler, 2012; Bybee, 2010). Breiner, et al (2012) found through their survey that there was no “common operational definition or conceptualization of STEM” (p. 9) among university faculty. They recommended that rather than seeking a universal definition for the meaning of STEM, the focus of the stakeholders should be on the outcomes: improving teachers and students so as to enhance the workforce of the United States.

Bybee (2010) presented ideas around what a STEM approach might mean for science education. The first is an acknowledgment that science education has been deemphasized because of No Child Left Behind. Instead, reading and mathematics are the major foci, since those are the areas that are being tested (Southerland, Settlage, & Brickhouse, 2014). Bybee’s second point is a call for increased prominence of technology education. He asserts that technology is has great influence on the lives of people but is little understood. In a similar vein, Bybee argues that engineering education should be enhanced since it promotes innovation and problem solving, skills the United States needs in its workforce to remain competitive. Finally, Bybee points out that STEM education, through student investigations and projects, provides opportunities for students to develop “21st Century skills” and explore the “grand challenges of our era” (p. 31).
Science Standards

For much of the 20th century textbooks and college admission requirements shaped what was taught in schools (Ravitch, 1995). During the mid-1960’s and 70’s scores on the SAT exam declined, and this brought attention to the need for national educational standards. In 1983 the report *A Nation at Risk* was released, which warned, “the educational foundations of our society are presently being eroded by a rising tide of mediocrity” (Gardner, 1983, p. 6). The report went on to recommend “schools, colleges, and universities adopt more rigorous and measurable standards…” (p. 24). In 1989 the National Council of Teachers of Mathematics (NCTM) released a set of standards (NCTM, 1989) which were intended to transform mathematics education. The goals of the NCTM standards were to increase students’ mathematical literacy and appreciation for math through five general student goals: that students (a) learn to value mathematics, (b) become confident in their ability to do mathematics, (c) become mathematical problem solvers, (d) learn to communicate mathematically, and (e) learn to reason mathematically (National Council of Teachers of Mathematics, 2000).

In 1991, at the urging of the president of the National Association of Science Teachers (NSTA), the National Research Council (NRC) put into motion an effort to create science standards (Collins, 1998). It was intended that the standards would influence science education by focusing on curriculum, teaching, and assessment. After a process that involved many organizations and individuals who explored, wrote, and conducted public reviews, the *National Science Education Standards* (NSES) were released in 1995. The NSES were voluntary standards, which were intended to “describe a vision of science education in which all students actively engage in inquiry to achieve understanding of natural events and phenomena” (Collins, 1997, p. 299). The NSES standards, along with the *Benchmarks for Scientific Literacy* written by
the American Association for the Advancement of Science (AAAS) (1993), were used as the basis for state science standards and assessment around the United States (Pruitt, 2014). Because of advances in both science and the knowledge of how students learn science, work began to update the science standards (Achieve, Inc., 2014). The process began in 2011 with the development of *A Framework for K-12 Science Education* (National Research Council, 2012).

*A Framework for K-12 Science Education* (National Research Council, 2012) describes a vision for science education that focuses on a smaller set of core ideas that included increased emphasis on practices and connections between subject areas. The framework is organized into three categories, or dimensions: (a) science and engineering practices, (b) crosscutting concepts, and (c) disciplinary core ideas. The science and engineering practices consist of eight practices used by scientists and engineers in their work. They are (a) asking questions and defining problems; (b) developing and using models; (c) planning and carrying out investigations; (d) analyzing and interpreting data; (e) using mathematics and computational thinking; (f) constructing explanations and designing solutions; (g) engaging in argument from evidence; and (h) obtaining, evaluating, and communicating information (National Research Council, 2012). The practices are independent of specific content and are meant to define ways for students to demonstrate and apply their knowledge, not as a list of activities they should follow (Pruitt, 2014). They are also intended to expand students’ views of science and the doing of science away from a single, narrow view of science as a set of procedures, e.g., the “scientific method” (p. 44), to include other practices, such as using models and making arguments.

The crosscutting concepts include seven ideas that are important to the nature of science and engineering and which have traditionally not been an explicit part of science instruction. The seven crosscutting concepts are (a) patterns; (b) cause and effect: mechanism and
explanation; (c) scale, proportion, and quantity; (d) system and system models; (e) energy and
matter: flows, cycles, and conservation; (f) structure and function; and (g) stability and change.

“These concepts help provide students with an organizational framework for connecting
knowledge from the various disciplines into a coherent and scientifically based view of the
world” (National Research Council, 2012, p. 83). They are designed to highlight the
interconnectedness found in nature and reduce the fragmented way that many subjects are taught.

The disciplinary core ideas include the core content knowledge that should be taught at
each grade level. They are organized around performance expectations that give examples of the
things students should know and be able to do. These core ideas are meant to be assessment
boundaries rather than curriculum topics and to inform the development of curriculum not
establish it (National Research Council, 2013).

**Next Generation Science Standards**

*A Framework for K-12 Science Education* (National Research Council, 2012) provided
the basis for the subsequent development of the Next Generation Science Standards (NGSS).
Achieve, Inc., facilitated the development of the NGSS, which was conducted primarily by the
National Research Council (NRC), American Association for the Advancement of Science
(AAAS), National Science Teacher Association (NSTA), and 26 lead states, one of which was
Washington. The NGSS were completed and released in April of 2013 (Achieve, 2014).

The *Next Generation Science Standards: For States, by States* (National Research
Council, 2013) is a two-volume handbook containing the Next Generation Science Standards
(NGSS). Volume one presents and details the standards, arranged both by disciplinary core ideas
and by topics. In addition, both the disciplinary core ideas and topics are further organized along
a grade-level progression from kindergarten to grade five and along grade bands for middle and
high school. Volume two contains 13 appendices and a glossary of abbreviated terms. The standards are presented as a set of assessable “performance expectations that state what students should be able to do in order to demonstrate that they have met the standards” (p. xxii). Most of the performance expectations include clarification statements that give examples or further clarify the performance expectation and assessment boundaries that prescribe the limits of assessments.

Also presented with the performance expectations are “foundation boxes” (p. xxv) that include connections to the science and engineering practices, crosscutting-concepts, and disciplinary core ideas outlined in *A Framework for K-12 Science Education* (National Research Council, 2012). Finally, links are provided that connect the performance expectations to other disciplinary core ideas at the same and different grade levels and to the *Common Core State Standards* (Common Core State Standards Initiative, 2015). Appendix B provides a more detailed description of the NGSS.

**Washington State Science Education**

Science, Technology, Engineering, and Math (STEM) efforts in Washington State have centered on state mandated graduation requirements and testing in STEM related disciplines and adoption of science education standards. Currently, high school students in Washington are required to pass two science courses, one of which must be a lab-based course, and three mathematics courses (Washington State Board of Education, 2013). The Washington State Board of Education (2013) has increased the science course requirement to three science courses, two of which must be lab-based, for students starting high school on or after July 1, 2015. There is no requirement for any specific science courses; however, students must pass the state Biology End-of-Course (EOC) exam. The state is planning to replace the Biology EOC after 2017 with a
comprehensive exam based on the Next Generation Science Standards (NGSS) (OSPI, 2013). Washington students must also pass an EOC exam in math. Currently there are three math exams from which students may choose: an algebra-based EOC exam, a geometry-based EOC exam, or the Smarter Balanced math test (OSPI, 2013).

Washington State developed the *Washington State K-12 Science Standards*, after the state legislature passed the Basic Education Act of 1993. They provided the vision for science education in Washington for several years and were revised four times before being replaced in 2013 by the Next Generation Science Standards (NGSS). The Next Generation Science Standards (NGSS) were adopted by Washington State following a four-step process conducted by the State of Washington Office of Superintendent of Public Instruction (OSPI) that consisted of (a) comparing the NGSS to the existing state science standards, (b) reviewing the NGSS to ensure that they were not culturally biased, (c) allowing for a time of public review and input, and (d) allowing time for the state legislature to come to an understanding of the standards (OSPI, 2013). It is expected that the NGSS will be fully implemented by the 2016-2017 school year and assessed starting the following school year (OSPI, 2013). The process of developing an assessment for the NGSS is just beginning.

When examining the Next Generation Science Standards (NGSS) as a policy instrument (Fowler, 2009; McDonnell & Elmore, 1987) it is important to note that, although the standards are intended to guide the behaviors of teachers and students, they do not require any specific actions. In addition, Washington State has not provided any state funding to support the implementation of the standards in schools. Schools and districts must make decisions about implementation individually and allocate resources from their regular budgets. Using the filter of Lowi’s techniques of control (Fowler, 2009), the NGSS would represent an example of a
regulatory policy. “Regulatory policies are formalized rules expressed in general terms and applied to large groups of people” (Fowler, 2009, p. 241). This certainly applies to the NGSS, as they are not specific in the actions they call for and apply to all schools in the state. However, the NGSS deviate from Lowi’s strict definition of a regulatory policy, which generally has penalties attached for noncompliance, and the NGSS do not address this issue. However, although at present there is no state assessment of the NGSS, Washington State plans to develop and administer an assessment of the NGSS starting in the 2017-2018 school year (State of Washington Office of Superintendent of Public Instruction [OSPI], 2013). Since graduation requirements are often attached to such assessments, students and school personnel will certainly feel pressure to attend to the standards and work to meet them. Teacher evaluations are also starting to be attached to standards. For example, in Washington State one of the models schools may use when evaluating teachers is the Marzano Teacher Evaluation Model (Washington State Teacher/Principal Evaluation Project [TPEP], 2013). The model rates teachers on the degree to which they understand and communicate established content standards.

Another way to look at policy instruments is offered by McDonnell and Elmore (1987), who outline four types of policy instruments: mandates, inducements, capacity building, and system changing. Another, hortatory policy, was added later to this framework (Fowler, 2009, p. 249). Mandates are rules that set the acceptable behavior of people and organizations. Inducements involve the transfer of funds in exchange for goods or services. “Capacity-building is the transfer of money to individuals or agencies for the purpose of investment in future benefits” (McDonnell & Elmore, 1987, p. 139) and is intended to “bring about major, permanent change” (Fowler, 2009, p. 253) to organizations and people. System changing policies involve
the transfer of authority to alter the way services are delivered. Finally, hortatory policies are intended to persuade individuals to act in certain ways.

When analyzing the Next Generation Science Standards (NGSS) using McDonnell and Elmore’s policy model (as presented by Fowler, 2009) it can be seen that because the NGSS do not allocate or reallocate funds or other resources it cannot be classified as an inducement or capacity changing policy. It does fit under the classification of a mandate but, as with Lowi’s regulatory policy, it is not a neat, clean fit. The standards are designed to alter behavior, but they are not specific in how this is to be done. The penalty for failing to do so, as previously described, is not attached directly to the standards but is indirectly enforced through other policy.

The Next Generation Science Standards (NGSS) are not a system change policy either, as defined by McDonnell and Elmore (1987), since the authority for educational standards continues to reside with the state. The NGSS simply represent a new set of standards chosen, instead of developed, under their authority. Since one of the functions of the NGSS is to communicate and persuade students, teachers and schools of the importance of its tenets and of behaving accordingly, they can be considered an example of a hortatory policy, which are designed to persuade individuals to act in certain ways.

In summary, the NGSS most neatly fit as a regulatory, policy mandate. The fit is not perfect since there is no direct penalty attached for failing to comply, but there is also no allocation, transfer, or reallocation of funds or resources accompanying them. They can be considered a hortatory policy since they attempt to influence the behavior of students and teachers by communicating information and guidance.
**Issues Surrounding Implementation of Education Standards**

When dealing with educational policy changes, teachers play a large and central role in determining whether, and to what extent, the policy is actually implemented. As intermediaries in the policy implementation area, teachers need both the will and capacity to put policy into practice (Fowler, 2009). Research has uncovered obstacles to policy implementation by teachers (Gross, Giacquinta, & Bernstein, 1971, as cited in Fowler, 2009). They include teachers not understanding the policy and not knowing how to make the changes called for. Having adequate resources, support from school officials, and maintaining their motivation were key for successful implementation. Research has shown that people are drawn to familiar ideas and tend to ignore those that do not fit their current understanding (Spillane & Callahan, 2000).

Given these issues teachers are likely to view the NGSS Disciplinary Core Ideas in light of the previous science standards and focus less on the Science and Engineering Practices and Crosscutting-Concepts. This is a very real possibility, as illustrated by a recent letter in the Seattle Times written by Jeff Charbonneau (2013), a Washington State science teacher and 2013 National Teacher of the Year:

> Teachers, parents and the general public should not find these new standards threatening. *They are not a radical change* [emphasis added], but rather are a carefully judged update and revision of what Washington students have been learning for years. Washington state has had standards-based science education for more than a decade.

**Teacher Understandings and Perspectives of Standards**

Little of the research that is done in this country involves the viewpoints of teachers (Seidman, 1998). A survey conducted in 1999 found that 73% of teachers generally supported standards based reform and 66% thought that standards had a positive effect (Caron, 2002).
Despite their favorable outlook, “teachers were frustrated by having to drop creative approaches to instruction from the curriculum in favor of test-preparation activities” (p. 73). Caron (2002) contends that teachers appear uncertain in their overall feelings about education standards, both supporting the higher expectations the standards represent and lamenting the changes they bring to their teaching.

Donnelly and Boone (2007) state that the concerns teachers may have around standards-based instruction can effect the way they use standards. Some of the teacher’s concerns were that standards create crowded, fragmented curricula that teachers would need to hurry through, teaching to standards-based assessments. Teachers also felt that their professionalism was reduced and that student-teacher relationships were negatively impacted.

In a science teacher survey study conducted by Donnelly and Boone (2007), 225 Indiana biology teachers were asked about their attitudes of the use of evolution standards in their classrooms. Their findings suggest that the evolution standards were useful to teachers as justification for teaching this controversial topic. The teachers also used the standards as a guide for time to spend on evolution. This may have resulted in a more thorough treatment of the topic.

There was a strong relationship between teachers’ attitude toward the standards and their use of them. If the teachers felt the standards were appropriate they were more likely to fully use them with their students (Donnelly & Boone, 2007).

**Summary**

Concerns about the United States’ ability to provide adequate science education to students, so that the country remains competitive in the world economy and its citizens have the skills and knowledge necessary to function in an increasingly complex society, led to the development of educational standards in science. The Next Generation Science Standards
(NGSS) are the most recent version of these standards and have been recently adopted by the State of Washington. Implementing new policy, such as the NGSS, is a difficult undertaking and requires that the implementation intermediaries, teachers, are involved in the process. Their understanding of the intent and demands of the standards is critical for successful implementation. However, to date, there is no extant research that has addressed science teachers' understandings of the intent and purpose of the NGSS and of their efforts to implement them.
CHAPTER THREE

METHODS

Introduction

The purpose of this qualitative study is to explore high school science teacher’s understandings and interpretations of the Next Generation Science Standards (NGSS), as well as their perspectives on implementing the standards in their classrooms. The research questions for this study are: (a) How are the Next Generation Science Standards (NGSS) impacting high school science teachers’ approaches to classroom teaching? (b) What are the challenges that high school science teachers are facing in attempting to use and implement the Next Generation Science Standards (NGSS) in their teaching? (c) What resources do high schools science teachers need to effectively implement the Next Generation Science Standards (NGSS) in their classroom teaching?

This chapter describes the methods used to explore these research questions. The chapter includes discussion of research methodology, qualitative interviewing, participant and site selection, data collection and analysis, ethical considerations, and my positionality as a researcher.

Methodology

In order to address the purpose and research questions, this study utilized a qualitative interviewing methodology. A qualitative interview approach is appropriate since I am attempting to understand the experiences and understandings of science teachers as expressed in their own words. Further, I employed a phenomenological approach to interviewing (Merriam, 2013; Seidman, 2013), using in-depth and open-ended interviews to fully explore participants’ experiences.
A phenomenological approach attempts to gain understanding of a person’s experience from their point of view. “The goal is to have the participant reconstruct his or her experience within the topic under study” (Seidman, 2013, p. 14). Interviewing is the principal method of collecting data (Merriam, 2009). Open-ended questions are generally used (Merriam, 2009; Seidman, 2013), which allow participants to reconstruct their experiences (Seidman, 2013) and which often results in rich descriptions and stories. Since meaning is contextual, time is taken to document the background of the participant to place their experience in context. Qualitative interviewing is ideal for learning about the issues people deal with in their lives and the meaning they make of them, that is, to gain their “subjective understanding” (Schultz, 1967, as cited in Seidman, 2013, p. 17), which is the purpose of this study. For this study, I conducted a single interview with each participant, using open-ended questions. Each interview lasted between thirty-five and sixty-one minutes, with the average interview being approximately forty-four minutes.

The instrument for data collection with qualitative interviews is the researcher (Merriam, 2009). Social constructivism posits that people create meaning through their interactions with other people (Atwater, 1996). This illustrates both potential strengths and weaknesses with qualitative interviewing. One such strength is that the participant, while answering a question, may develop a deeper understanding of an experience than they already possessed, perhaps because they had not previously thought about it deeply (Merriam, 2009). Another is that during open, in-depth interviews, the interviewer has the opportunity to direct the course of the interview with follow-up questions and probes (Seidman, 2013). This not only allows the researcher to better fill in gaps in the data, but also helps make connections between different experiences described by participants. Careful, active listening was required during the
interview. In this study, while listening to participants’ responses I made every effort to pay attention to their body language and nonverbal cues and to limit my comments. I asked follow-up questions as they seemed appropriate, to encourage the participant to elaborate on some aspect of an answer to a previous question.

A potential weakness of qualitative interviewing arises because the interviewer is the primary instrument of data collection. As the primary instrument, researchers must be aware of their personal biases, which could influence their interpretations. Their philosophical perspectives shape the structure of the interview, the type of questions they ask, to what they attend, and how they interpret the data. The interviewer is part of the interview (Seidman, 1998), and their interaction with the participant can affect the responses. I examined and was aware of my personal biases and attempted to set them aside during the interviews, so as not to “contaminate” the responses.

Reliability and validity considerations are different for qualitative and quantitative studies. Golafshani (2003) goes so far as to suggest, “the concept of reliability is irrelevant in qualitative studies” (p. 601). Seidman (2013) concedes that while researchers may strive to allow the meaning being made to be that of the participant alone, “the meaning is, to some degree, a function of the participant’s interaction with the interviewer” (p. 26). Comparing the comments of multiple participants is another way to increase the “trustworthiness” (p. 17) of the interview study’s findings. Another “validity” mechanism is “member checking” (Merriam, 2009; Seidman, 2013), which means allowing participants to review and potentially correct data they have provided. In this study, I attempted to enhance trustworthiness by comparing the comments of multiple participants, and through member checking by providing participants with
a transcript of their interview and inviting clarification. In addition, I contacted one participant after her interview to ask her to comment on an idea that was expressed by other participants.

As discussed in chapter one, ethical treatment and considerations should always be at the top of any researcher’s list of priorities. Participants had the right to decide to participate or refuse, and to withdraw from participation at any time without any repercussions. Since it is possible that a participant could be harmed by something they say during an interview, I took steps to protect their confidentiality. The names of participants and schools were replaced with pseudonyms in the final draft of my dissertation. I believe that there is minimal potential for harm for participants of this study.

“Participants also have the right to gain something from a study” (Cresswell, 2008, p. 12). A researcher profiting from a study in which participants have given of their time and energy without considering their interests risks exploiting them (Seidman, 1998). In this study, teachers may have enjoyed telling their stories and may have benefited from reflecting on their answers to the questions. In addition, I presented each participant with an Amazon gift card as a small token of my appreciation. Combined, all of these considerations help the researcher maintain the respect and dignity of their participants, which is the researcher’s cardinal responsibility.

Seidman (2013) provides a model for conducting in-depth phenomenological interviews, which I used as a guide for this study. His model calls for conducting three consecutive 90-minute interviews with each participant, spread out over a time period of one to three weeks. The purpose of the first interview, according to Seidman (2013), is to glean as much information about the participant as possible relative to the research topic. Topics might include earlier experiences with family, school, job, friends, mentors, etc. The second interview is intended to
gather information about the details of the participant’s current situation. The topics for the questions could be describing their relationships, careers, duties, and the like. Open-ended questions are used to illicit stories and concrete details of participants’ lives. In interview three the researcher asks participants to reflect on their experiences and make meaning of them. Seidman (1998) emphasizes that this third interview will only be effective in as much as the first two established a foundation for it. During the interview, participants may be asked to describe how their experiences affect them and how they make sense of them. This is the stage in the process where participants discuss their emotions and opinions and make connections between different aspects of their lives and how they interact. Each interview provides the foundation for the next, and so Seidman emphasizes the importance of conducting all three. That being said, he does acknowledge that the number and spacing of interviews could be changed, as long as the integrity of the basic structure is maintained.

For the purposes of my study, I used a modified version of Seidman’s (2013) three-interview structure with only one interview with each participant. While I am convinced that conducting all three interviews in Seidman’s model is best, I had some practical concerns about being able to accomplish it. My first concern was for the demands that three, 90-minute interviews would place on my participants. To minimize the burden caused by participating in my study, I interviewed each participant only once. Preparing transcripts from audio recordings is a time consuming and costly endeavor. By conducting fewer interviews the cost for transcribing them was significantly reduced. I kept the duration of each interview to between 60 and 90 minutes. I believe that the essence of the three-interview structure can be maintained while also honoring participant’s time and sacrifice.
The focus of the first part of the interview was to collect background and contextual information about the participants’ experiences and beginnings as science teachers. First, I asked open-ended questions to learn about the participant’s background, education, and experience. I hoped that these questions, being fairly easy to answer and nonthreatening, put the participant at ease so that they would more readily answer deeper questions later. Next, I asked in-depth, open-ended questions to try and learn as much as possible about the participant’s current experiences as a teacher as well as their experiences with standards. The aim of the first part of the interview was to establish a context for their feelings and opinions relative to their lives and careers (Seidman, 2013).

During the second portion of the interview I employed open-ended questions with the main objective to encourage the teachers to share their thoughts and feelings about the Next Generation Science Standards (NGSS). Questions were crafted to uncover participants’ current understanding of the NGSS and its structure. Do they see it as something new, or just as a repackaged version of existing standards? Do they see it changing the way in which they do their work? If so, how? Finally, I asked questions designed to encourage the teachers to describe what meaning the NGSS have for them and their careers.

**Participant and Site Selection**

This study used purposeful sampling to select participants, high school science teachers who have similar experiences, thus constituting information rich cases for study (Patton, 2002). Selecting from similar urban and suburban schools allowed for a common picture of what these teachers deal with in their professional lives. High school science teachers were selected from three school districts in and around Spokane, Washington. The districts I selected have a combined total of nine high schools and around 100 science teachers and are typical for the area.
I focused on high school science teachers because they face similar instructional challenges since high school students must pass the state mandated science assessment in order to graduate. In addition, eligible participants had at least five years experience teaching science, so that their experiences were not overwhelmed with the issues and challenges that new teachers face.

Further, selected teachers had some familiarity with the Next Generation Science Standards (NGSS) because this study is exploring implementation challenges. For example, some teachers have participated in professional development focused on some aspect of the NGSS, collaborated with other teachers around implementation of the NGSS, or have done personal study and exploration of the NGSS. I teach at one of the high schools in one of the districts being used in this study, so teachers from my school were not included as a site for this study to avoid the possible pitfalls of which Seidman (2013) warns. These include distorting the interview process to avoid harming the relationship between the researcher and participant, perhaps by not asking follow-up questions involving uncomfortable situations. It is difficult when interviewing colleagues and friends for the interviewing relationship to develop on its own since a relationship already exists. In addition, friends and colleagues will often assume that they understand each other. This can result in less probing for clarity and for underlying assumptions. Seidman asserts, “the interviewer and the participant need to have enough distance from each other that they take nothing for granted” (p. 46).

Seven science teachers were chosen. Seven teachers is a feasible number who could be readily contacted and still provide sufficient variety and density of data. The costs for data collection and analysis, both monetary and time, were also factors in limiting the study to seven participants.
The student population of the largest of the three districts that I targeted accounts for approximately 52% of the combined population of the three districts. Since there are eight high schools available in the districts selected, and in an attempt to maximize variation among participants, one teacher from each high school was initially contacted and asked to participate. A list of science teachers from each high school was compiled, based on information available from district and school sources. The names of science teachers from each high school meeting the selection criteria were entered into a spreadsheet and then randomized. These lists were then used, starting from the top of each list and working down, for making initial contact with teachers until seven science teachers agreed to participate. Four teachers were chosen from the largest district and three from the remaining two districts.

Initially, an email was sent to the randomly selected potential participants. The email introduced me, outlined the purpose of the study, and provided an overview of the study’s methods. Contact information was provided so that potential participants could call or email me with any questions. In addition, as a courtesy, an email was be sent to the principal of each selected school detailing the purpose and methodology of the study, my criteria for selecting and contacting teachers, and my contact information.

A few days later, personal contact was initiated through a telephone call. The purpose of this was to further explain the nature of the study and what participation would entail in terms of commitment, risks and benefits, and to formally ask the teachers to participate. Not all of the teachers who were contacted by telephone agreed to participate. This initial telephone contact constituted the first step in the informed consent process. Teachers were not asked to sign the informed consent form until the time of the first interview, when I went over it with them and allowed them to consider it fully.
Participants

Of the seven participants of this study, four were female and three were male. Their experience as science teachers ranged from eight years to 24 years. To help preserve the confidentiality of the participants, pseudonyms are used for their names and the names of the school districts in which they work.

Janice has been teaching high school biology in the Prairie school district for six years. Before that, she worked as a long-term substitute teacher in a different school district. She earned a bachelor’s degree in education with a major in biology and later earned a masters degree in science education. Previous to becoming a teacher, Janice worked in the service industry, including at banks and hotels. She says that she wants her students to “actually do the process of science. To learn, to explore, to investigate, to ask the questions, to actually analyze data as opposed to just content.”

Katherine says that she came to science education naturally because she “grew up in a science education family.” Her father is a researcher at a college, and during her youth Katherine was able to accompany him into the field. At around the age of 16, she started working for an archeological project that paired researchers with students and educators doing actual research and learning scientific methods. Katherine’s formal education includes a bachelor’s degree in environmental studies and another in social work. She has a teaching certificate with a biology endorsement, a master’s degree, and an administrative certificate. Katherine currently holds a part-time position within the Centennial school district where her duties include facilitating the preparation of curriculum guides and textbook adoptions for science classes in the district. Katherine says that her philosophy of teaching is that “we are born learners and we have a drive
to learn, and that sometimes, unfortunately, the experiences that the students have in a formal education environment start to shut down some of that natural learning drive.”

This is Kyle’s second year teaching science in the Prairie school district. He teaches at the same school as Janice. Kyle says that his goal is to “...get them [his students] excited about science and make them enjoy their experience and want to come back for more...” Before teaching at his current school, Kyle taught for seven years at a community college. He holds a bachelor’s degree in biology, with a pre-med focus, and a master’s degree in kinesiology. Kyle has taken a leadership role at his school, working with others to develop a freshman physical science course based on the Next Generation Science Standards (NGSS). It was decided that in the Prairie school district this course would be a project-based course. Kyle’s role has been to adapt curricula to fit into a project-based environment while also ensuring that the appropriate grade level standards are addressed.

Nora is a veteran science teacher with 24 years of experience. She has earned a Bachelor of Science degree in biology, with a minor in physical science, and a master’s degree in curriculum and instruction. Over the years, in addition to her teaching duties, Nora has coached track and cross-country running. She says that she has no particular teaching specialty since she has taught a variety of science courses during her career, including biology, physical science, general science, and chemistry. Her current teaching assignment is teaching chemistry and advanced placement chemistry. Nora says that her teaching philosophy is “that each student that walks in the door comes to me with different levels of ability and that it’s my job to teach them, to find a way to make that student be successful.”

Ron is native to central Washington and earned degrees in chemical engineering and forestry. Before becoming a teacher, Ron worked for eight years as a chemical engineer at a
paper mill. Dissatisfaction with that career path led Ron to return to school, earning a Master’s in Education (M.Ed.) degree. Ron initially taught physical science in a school with grades seven through 12. After a few years he moved to a high school where he eventually taught chemistry. On occasion, he has also taught math. Ron’s current assignment is teaching four sections of general chemistry and one section of advanced placement chemistry at a high school in the Timber Creek school district. When Ron describes his approach to teaching he says “I want to give the students a real, practical understanding … whether it be through demos, labs, or practice … constantly bringing it back to where does what we’re doing fit in the real world.”

Samuel has been a science teacher for about 24 years and has, by far, the most varied background of all the teachers that participated in this study. Samuel was born and raised overseas and, for a while, taught at a university in his native country. His undergraduate degree is in general agriculture. Later, he earned a master’s degree in agricultural education, and for a while studied engineering in Asia. Finally, Samuel holds a Doctor of Education (Ed.D.) degree, specializing in educational leadership and has an administrative credential. Samuel taught in another state for about five-and-a-half years and has been teaching at his current high school in the Centennial school district for about 18 years. Samuel feels that his experiences living in different cultures, and his pursuit of an advanced degree, have “informed who I am as a teacher”. Samuel feels that “there has to be a connection [with his students]. There has to be a sense that when they come in there, I’m the advocate, and that I actually want them to succeed. And then, from there, we can work together…”

Troy has taught science at the same high school in the Centennial school district for nearly 20 years. He has a degree in biology, with additional teaching endorsements in chemistry, general science, and physical education. He is currently the science department lead at his
school where he teaches biology and outdoor living, but he has taught nearly every course that his school’s science department offers, including biology, chemistry, physics, integrated science, and physical science. Troy also coached football, wrestling, and track during his tenure. Before teaching, Troy worked 15 years for a large supermarket chain. This allowed him to put himself through school. He continued to work for them, part time, for the first four years of his career as a teacher. Troy says that he is “a firm believer in hands-on science and I try and create or find different hands-on activities that will get my kids out of their chair and actually go out and experience some kind of science…”

**Data Collection**

Data was collected using phenomenologically oriented interviews. The interviews provided a vehicle for “understanding the experience of other people and the meaning they make of that experience” (Seidman, 2013, p. 9). I conducted one in-depth, open-ended, semi-structured interview of each teacher involved. Ninety minutes were allowed for each interview. The interviews were conducted at a location mutually agreed upon and convenient to the participant. The location chosen was private and quiet, with a low likelihood of frequent interruptions. The interviews were recorded with a digital audio recorder.

**Data Analysis**

The audio recordings of each interview were transcribed verbatim into a Microsoft Word file by a transcription service. A confidentiality agreement was made between the transcription service and myself before any recordings were sent to them. I compared the transcripts to the audio recordings by listening to the recordings while simultaneously reading the transcripts to ensure accuracy. Any needed corrections were made at that time. The Word files were then reformatted to include extra-wide margins on the right, for marginal notes, and line numbers on
the left for easy recall of specific passages. Member checking (Merriam, 2009; Seidman, 2013) was attempted by providing copies of each transcript to the corresponding participant who indicated an interest, so that they could check for accuracy and for clarification.

During initial readings of the transcripts, an effort was made to let ideas and concepts emerge as I read. In other words, I was not looking for any particular ideas or concepts. While reading, the transcripts were marked, indicating passages that seemed to discuss a significant idea or that provided useful “in vivo” terms (Creswell, 2008). I underlined and highlighted important sentences and passages and wrote marginal notes that summarized or described the idea contained in the relevant passages. When this was completed for all of the transcripts, the transcripts were reexamined. During this second reading of the transcripts I marked passages in the text with two-letter codes that I created, which categorized the important ideas present in the text. When a new idea emerged for which a category did not already exist, I created a new one. In the end, 15 different categories emerged. A third reading of the transcripts was conducted during which the comments made by the teachers, identified by the codes, were transcribed onto color-coded index cards. Three colors of index cards were used, a different color for each of the three research questions. Once all of the transcripts had been examined, the index cards containing the extracted data chunks were analyzed. The cards were sorted and grouped according to emergent themes based on similarities between the ideas they contained. Once all of the sorting and re-sorting was complete, four themes had emerged: (a) impediments to implementation, (b) the contextual nature of implementation, (c) impact of implementation on teachers, and (d) needed supports for implementation. Finally, the transcripts were read again to check for any passages that may have been missed or that did not initially seem relevant but now seem to apply.
Ethical Considerations

To reduce the chances that participation in this study will cause harm, I took steps to ensure that they were properly informed before they agreed to participate, that the participant’s confidentiality was preserved, and that they were respected during the study. I fully discussed what participation entailed, including what possible harm they could experience. The participant’s confidentiality was protected by making sure that records of their interviews were stored securely and that their real names, and their schools’ names, were not used in the final writing of this dissertation. I always strove to treat my participants with respect by honoring their time and concerns for how this study might impact them personally or professionally.

Positionality

As discussed in chapter one, I have personal and professional motivations for conducting this study, as well as strongly developed views on science teaching and the potential positive impact of the Next Generation Science Standards (NGSS). In addition, in regard to my stance as a researcher, I am attracted to phenomenology because it allows me to uncover the “lived experiences” (Merriam, 2009, p. 24) of high school science teachers from their perspectives. In addition, a phenomenological interview approach complements my views on social constructivism, where meaning is created through interactions with others (Atwater, 1996).
CHAPTER FOUR
ANALYSIS

Introduction

The purpose of this study is to explore the challenges faced by Washington State high school science teachers in regard to implementing the Next Generation Science Standards (NGSS) in their classrooms. The study focuses on how the adoption and implementation of the NGSS places demands on the practices of science teachers, how they perceive the problems associated with implementing the standards into their curricula, and, in general, how the implementation of the standards might be impacting their teaching approaches. This study did not intend to explore specific classroom instructional methods associated with implementation of the standards.

Seven science teachers from five different high schools in Eastern Washington were interviewed using phenomenological interviewing techniques, as described in the previous chapter. In this chapter, I will discuss the themes and sub-themes that emerged through qualitative analysis of the data collected during the interviews.

I identified four overarching themes during the analysis: (a) impediments to implementation, (b) the contextual nature of implementation, (c) impact of implementation on teachers, and (d) needed supports for implementation. These themes provide a framework for understanding the challenges high school science teachers face in implementing the NGSS in their classrooms, how the NGSS are impacting teachers’ approaches to teaching, and what resources and supports are needed by teachers to help them implement the NGSS.
As these themes are discussed in the following sections, pseudonyms are used to identify participants. As explained in chapter 3, the participants include three females and four males, with experience as science teachers ranging from eight to 24 years (see Table 1).

Table 1

Participants

<table>
<thead>
<tr>
<th>Participant (Pseudonym)</th>
<th>Gender</th>
<th>Ethnicity</th>
<th>Years of Experience</th>
<th>School District (Pseudonym)</th>
<th>Subject Expertise</th>
</tr>
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<td>Female</td>
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<td>Prairie</td>
<td>Biology and Science Education</td>
</tr>
<tr>
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<td>White</td>
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<td>Centennial</td>
<td>Biology and Social Work</td>
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<tr>
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Impediments to Implementation

Three subthemes were identified related to the main theme of impediments to implementation. One of the subthemes is about teachers’ reluctance to fully implement the Next Generation Science Standards (NGSS), the second subtheme describes impediments to implementation due to the lack of resources or training, and a third subtheme relates to teachers’ possible limited understanding of the NGSS and the perception that they are already doing what the NGSS calls for.
Teachers’ Reluctance

In regard to teachers’ reluctance, the first issue involves fears expressed by teachers in regard to teaching unfamiliar content and whether their efforts would have a lasting effect. Janice explains a fear she has observed in other teachers: “I know that the one thing that…most people are afraid of the most is the engineering portion of it, because they see it as such--specifically like in engineering, like designing things as opposed to kind of a problem solving.” However, she is not herself as worried: “I don’t see it as a great challenge. I mean, to me it seems pretty…doable.” One fear that she does share with other science teachers is that her efforts at implementing the NGSS will eventually come to naught. She states,

You know, my one fear…is the same thing that everybody talks about and grumbles about… are we going to put all these time [sic] and effort into changing things and then five years you have to change everything all over again…. It’s not the additional time put into, you know, changing the units a bit. It’s not having to drag the old timers into it. It is the concern that…we go through so many changes in education in the small amount of time that I've been here. Are we going [to] spend all these [sic] time and effort and then just five years down the road, throw it back out the window and start over with something new?

In contrast, a second issue related to teachers’ reluctance relates to teachers’ negative evaluation of the NGSS. Ron, a veteran teacher of 17 years, represents this view. Ron appears to be reluctant to change his teaching to fully implement the NGSS, although he says he would do so since it is his job. His reasoning seems to be based on his opinion that the NGSS are inappropriately too deep and broad for most high school students and that most students will be unsuccessful under the new standards, because they are not yet intellectually mature enough to accomplish what the NGSS requires. He states,

Well, I keep looking at them [the standards] and I particularly look at the chemistry ones. And some of them concern me --next gen, to my understanding, is supposed to be what every high school student should have an understanding of by the time they graduate, and the document, as I read it, is much closer to, “Here’s my dream child going into college”. For instance, when I look at the matter and interactions and I see they have “refine and
design a chemical system by specifying the changing conditions that would produce increased amounts of products” to the equilibrium clarification statement. “Emphasis is on the application of Le Chatelier’s principle and refining designs of chemical reaction systems including descriptions and connections.” I’m going, are you out of your mind? My AP students struggle with Le Chatelier’s principle and you didn’t say excluding it. You specifically said, “This is with an emphasis on Le Chatelier’s principle”…. Does it belong in a document that’s designed for all high school students? I don’t think it does…

Thus, Ron is not confident that teachers and schools will be successful in implementing the Next Generation Science Standards (NGSS). He anticipates attempts to teach some of the concepts as being “a disaster” and that he would “lose 80% of my kids.” Ron’s reluctance to embrace and implement the NGSS seems to stem more from a concern for his students and his own success as a teacher, and not from clinging to comfortable and familiar ways.

In contrast, a third issue related to teachers’ resistance is a reluctance to change what they have been doing in their classrooms for several years. This concern was mainly expressed by veteran teachers. Janice described the issue this way: “…they have their activities that they do. They have their labs that they do. They have their worksheets that they do. They want to stay with that.” Kyle expresses a similar view when he discusses how much of his school’s existing curriculum does not align well with the NGSS and will need to be changed. He suggests that some of his colleagues are reluctant to change because they may feel that “I’m close to retirement, I don’t want to learn a whole bunch of new stuff right now.” The reluctance of some teachers to make changes in their curricula or teaching methods presents challenges when collaborating with other teachers. Janice describes her frustration: “I think that the challenge is working with other people within the department…[who] don’t want to change at all.” She later adds, “I see these activities that are kind of these…sacred cows that they’ve been working with…I feel like we’re just doing this…because we’ve already done this.”
As an example of how some teachers may be reluctant to change what they have been doing in their classrooms, consider Nora. When asked if the NGSS were having any effect on her teaching she said,

Absolutely not. I know what the standards are, and I’ve seen them, and I’ve looked at possible scenarios with those. And I am very good at compartmentalizing, and I would suggest that what I’ve done is said, “I know I’m going to have to change between now and when I retire. And I’m going to wait and do it then,” which is functional procrastination on my part with the…implementation of the standards. I don’t think they are changing what I’m doing at all, except for when I had a student teacher last year, and we spent a great deal of time talking about how she was having to implement all of the standards into her lesson…

This statement suggests that implementation may not occur unless teachers are given a reason to do so.

**Lack of Resources**

Despite the fear that the work they are doing to implement the Next Generation Science Standards (NGSS) may not last, teachers like Janice continue to adapt their curriculum and teaching. When doing so they face a lack of adequate training, instructional resources, and collaboration time. Janice states: “I haven't really found a lot of resources. I've seen activities. Like, here’s a good activity that you could use but, you know, I would like to see what a whole unit should look like, you know, what’s their vision of that.” A lack of technology, computers and computer-based probeware is also a problem for both Kyle and Janice. Kyle explains: “The biggest drawback…is just the technology with we [sic] are not at our school very well equipped for next gen standards as far as what we could and should be doing.” Janice agrees:

I know for myself, at my school, technology would be super awesome great, because if I want the kids to be doing research, I want them to be doing real analysis of data. If I want them to be working and making like Excel Spreadsheets instead of little line graphs, I need to have the technology; and without that, I mean, I don’t see how I can make them do what I think that we’re being asked to have them do…
Virtually all of the teachers interviewed discussed a lack of time as a factor inhibiting implementation, including time to collaborate with other science teachers, time to adapt curriculum to align with NGSS, and time to work with students. Many schools, including Janice’s, have some limited collaboration time for teachers built into their schedules. Janice feels that this time is inadequate. She states,

The resources that I could use would be time, time to work … not before school or after school in an hour chunk here but actually good chunks of time to sit down together and hammer these details out…look at the NGSS and look at what we're doing, work together, put it together. You know, that’s not going to happen if we…meet every Thursday for an hour, you know. We need real chunks of time to work together.

Janice also describes challenges associated with the time it takes to adapt curriculum, saying,

I think that the demand is primarily, to me, a time thing…it does require a change in the way that we’re teaching the material now, which will obviously require some time to re-develop some of the curriculum.

Kyle echoes this idea when he says,

And there’s a whole another set of things, you know, to all these labs and all these things that people put a lot of time and energy into doing that are either outdated or no longer align that are going to have to be changed. And that’s… going to take a lot of time and energy to get those things switched.

**Limited Understanding of the NGSS: “We are Already Doing This”**

During the interviews conducted for this study, several of the teachers made comments indicating that they felt they were already doing what the Next Generation Science Standards (NGSS) was asking them to do. Samuel, who has had some professional development around the NGSS, makes these comments:

So, you’re doing these things like we’ve always been doing but it’s just that the focus is going to be more on science, engineering, technology and following… science and engineering… practices and also making sure that what the kids are doing… is something that they can apply.

But if you look closely… that’s stuff we’ve been doing all along. We just could be making a lot more focus as our goal. So, what we did in our school is, we went…sat
down and took the NGSS… standards and tried to analyze what the performance, you 
know, expectation would be, analyze what does it contain. Now we know what it 
contains, it’s like, “Oh, geez, that’s stuff we’re already doing.”

Troy describes how, when he started to “take a look” at the NGSS, many of the topics presented 
were similar to ones he already teaches.

I don’t know 100% yet, but from what I’ve looked at and the ones that I do, kind of look 
through and try to start to match up, I find that I think we’re doing a lot of things that are 
very similar. They might not be exact, but they’re very close and I think with some 
modification that we can slide some of these things in there, some things with 
engineering practices and building things…

In holding these opinions, both Samuel and Troy seem to be interpreting the NGSS in a certain 
way, that is primarily focusing on the NGSS content, or the disciplinary core ideas (DCI’s), 
rather than science and engineering practices (SEP’s) and crosscutting concepts (CCC’s), all of 
which are fundamental facets of the NGSS as explained in the literature review (National 
Research Council [NRC], 2012). Nora expresses this idea in a more direct way.

I would bet if I laid standards…if I lay the NGSS standards down in front of me that have 
to do with the physical sciences and specifically in the chemistry, I think I would be able 
to say check, check, check. I do that. I just wouldn’t be probably doing the overarching 
ideas, the applications to engineering, the applications to whatever other areas that I may 
or may not be doing, because I probably am more curriculum-driven as oppose to 
approach-driven or big-picture…. I don’t know what percentage that is. But I would bet 
with the two I recall seeing that were specifically about chemistry, we cover it. But the 
other material that is science in general that I should be approaching in chemistry, I may 
or may not be doing that at all.

These opinions suggest a limited interpretation of the NGSS, a claim further supported by 
Katherine’s comments. Katherine’s part-time leadership role within her district affords her the 
opportunity to work with many teachers. She describes two interactions with science teachers in 
her district, which provide support for the idea that teachers may not change their teaching when 
implementing the NGSS because they do not realize that the SEP’s and CCC’s are integral parts 
of the NGSS:
I had a teacher bring in the list of DCI's and the list of our old standards, and he set them side by side in front of me and literally said..."see, I'm already doing NGSS." I asked him about how he teaches this content within the context of SEPs and CCCs and he gave me a blank stare. Once teachers are deeply introduced to the SEPs, and CCCs, they usually realize they haven't made the instructional shift NGSS asks of us...even if the content between the two sets of standards more or less lines up.

She continues:

I had another teacher re-write lessons with some changes in content and vocabulary derived from studying the NGSS DCIs, [Disciplinary Core Ideas] but no changes in delivery method, no shifts in instructional practice, no new experimenting with student inquiry. Same basic "stand and deliver, sit and get" approach. This teacher declared the lessons now NGSS aligned. So...there is a high need for deeper level professional development and ongoing specific classroom-based, lesson-by-lesson consultation, support and accountability check-ins as teachers learn what the shifts look like in their lessons, in their classrooms.

Summary

Implementation of the Next Generations Science Standards (NGSS) presents new and varied challenges for teachers. Teachers may be reluctant to change what they are currently doing because it removes them from their comfort zones or they are close to retirement, because they do not agree with the appropriateness of the Next Generation Science Standards (NGSS), or because they are not confident that the work they do now to implement the standards will still have meaning in a few years. If teachers do not fully understand the facets of the NGSS and believe that they are already implementing them because they are already covering the same “material,” or content, it may be very difficult to reach the goals the NGSS presents.

The Contextual Nature of Implementation

Implementation efforts by the teachers in this study varied from one location to another. For teachers in some districts the Next Generation Science Standards (NGSS) served as the guiding document for developing their curricula while for teachers in other districts they played no role at all. The specific school district’s administrative expectations or district initiatives
seemed to play a role in whether teachers concerned themselves with the NGSS and to what degree.

Kyle and Janice, who both teach at Pinewood High School (a pseudonym), were further along with NGSS implementation than were the other teachers interviewed. Kyle explains,

Our district, I feel like, without knowing what other districts are doing, set some pretty good foresight into, hey, we should probably start implementing this instead of just in three years…

He explains how thinking about the Next Generation Science Standards (NGSS) has become central to his practice: “I mean everything I’m doing now is all about next gen.” Likewise, Janice was an early adopter of NGSS, because, as she explains,

I see it as when I was in school, did I really want to just sit there and do it the way that we used to do it, just like all lecture, lecture, lecture, test. I mean, I learned OK that way, but I don’t think it was very enjoyable, you know…. I like science and I’m passionate about it and I see how much people don’t understand science outside of…[the] scientific community … and I want them to understand it. And I think that in order for people to understand science, you have to teach them good science. You have to make them interested in science. You have to show them the process of science because if you just tell them facts, people forget little tidbits all the time. But I think when you teach them how to actually do science, how to analyze science, how to, you know, look at science, that I think, to me, it makes it a better … world. I want to say science -- science-literate people and I think that that’s, you know, I have a role in that. That’s my job.

Janice describes how she became involved with early efforts by her district to include the standards in the districts science curriculum:

…when it came up that we were going to have a committee to start incorporating them [the NGSS] into the curriculum, since I’d already started looking at them and kind of trying to work with them myself, I volunteered to work…

Samuel’s situation provides some contrast. He teaches at Douglass High School (a pseudonym) in a district neighboring Pinewood. His high school was a recent recipient of a grant to fund efforts to increase the graduation rate at Douglass. Samuel participated several years ago in a small group of teachers from within the district, led by the district’s science coordinator,
which reviewed the NGSS. While this experience has kept the NGSS in the mix when Samuel plans his science lessons, he doesn’t feel that he is incorporating them at the level he would like:

Well, right now, we are not getting a full implementation…. As a science teacher, it’s always influenced my … approach to teaching. It is not happening at the level that we expect to get to where, when you’re planning your lesson…[when] you’re focusing on your performance, you know, expectations.

He continues, “So, you’re doing bits and pieces of what we expect to implement fully when we get into NGSS, but we are not at that level yet.” The efforts that Samuel’s district made early in the adoption process for the NGSS had an impact on Samuel, but those efforts were not continued when the science coordinator left. In addition, the overall school improvement initiative at his school overshadows any real implementation efforts of the NGSS.

In the same school district as Samuel, Troy’s situation is similar. He is a teacher and science department lead at Ponderosa High School (a pseudonym). When Troy discusses how the Next Generation Science Standards (NGSS) are impacting his approach to teaching, he says,

Well, honestly, we're looking at those standards now. I wouldn’t say that we've implemented a ton of them…. We're still following district standards and state standards, but we're starting to look at those national standards, the NGSS, and trying to figure out how are they going to meld into what we're currently doing …how is that going to have to get remodeled to match up so that we can blend them, you know. So, that’s kind of where we're at right now.

Troy indicates that implementation efforts at his school are in the early stages, with the science teachers just starting to examine the NGSS. The standards do not appear to be a priority for him, and presumably for his department. As evidence of this, Troy states that they are still “following district standards and state standards” despite the fact that the State of Washington adopted the NGSS as state science standards 27 months prior to Troy being interviewed for this study.

Ron represents another contextual situation. He teaches in another school district at Tamarack High School (a pseudonym). As mentioned earlier, he appears reluctant to fully
implement the NGSS because he is concerned about their appropriateness and is not confident in his prospects for successfully teaching students in alignment with the standards. Despite these views, he describes how the standards are, nonetheless, affecting his teaching:

I think the one aspect that’s changed a little bit, there’s an engineering design application to this things [sic] that it did encourage more of this idea of having a lab where you were trying to specifically solve a problem…. Where there is a variety of ways that you can solve the problem, kind of. It was like an engineering design problem. So, because I’ve seen… that there’s a value for that, I’d like them [the students] to have some experience with it.

During his interview, Ron does not mention any school or district-level initiatives around implementing NGSS. This suggests the possibility that there may not be any official initiative in his school or district in this regard. Ron’s motivation for implementing the NGSS seems driven by his statement “that all depends on whether or not my kids are actually going to be tested on that.” This suggests that, in the absence of external pressure, such as a state exam, implementation efforts may not be a priority for science teachers.

Summary

The comments of the teachers interviewed for this study reveal a range of implementation efforts for the Next Generation Science Standards (NGSS). These were influenced at least somewhat by the context in which the teachers found themselves. In schools and districts where officials signaled the value or significance of the NGSS, implementation efforts were more pronounced. In cases where there was a lack of a sense of accountability, urgency, or value, implementation efforts were minimal to nonexistent. It seems clear that leadership is needed at the district level in order to achieve an adequate and consistent level of implementation of the Next Generation Science Standards (NGSS).
Impact on Teachers

The teachers in this study alluded to the Next Generations Science Standards (NGSS) potential impact on their teaching approaches. Ron relates how his classes are changing to accommodate the additional student focus and active participation called for by the NGSS:

So, you know, [I’m] trying to come up with more labs that maybe have them [the students] thinking about applications and things like that. I guess, in that sense … I’ve used the next gen to try and design some that are more applicable…

Nora is a veteran teacher who is obviously comfortable with the way she has been teaching for many years. When asked how the NGSS might affect the way she teaches she shares some of her thoughts and concerns:

…There’s also going to be teaching style. OK, [name deleted], you’ve been teaching like this for the last 25 years here at [school name]…. how are you going to change this up because now here’s what you have to do. This is…these are the measures…that you need to have your students meet, and how are you going to go about doing that? That’s— I’m not saying that that can’t be done, of course, it can be done. We can all…learn and do something different, that’s not the problem. But I think that there will need to be some significant time spent on that….

Nora’s concern is not only with changes she may need to make to the way she teaches, but also to the kinds of things she may need to teach. She explains:

It might be something that’s like as [sic] big ongoing project and the lessons pertained to that project, and the research pertains to that project, and…how would this look in the real world? What would you be doing in a career, you know, all of that if you were to go into college? What would you, you know, when you go to college what would you be doing? I mean, I think that there’s all sorts of facets to it. It feels a little bit overwhelming, quite honestly, but I’ve been at this for a long time so that’s probably why it feels overwhelming to me when I look at it. When I’ve seen the documents, I’m like, wow, OK, it’s big. It’s big.

Kyle shares some of the same concerns as Nora. He describes his feelings about changing to project-based teaching:

And then by switching to project based, a big challenge for me is all I’ve ever taught is lecture classes at the college. So it’s turning them loose to have 25 to 30 kids running around building stuff, maybe working…that apprehension of, oh my goodness, what is
going on in here right now versus just having a thumb on them...and that’s just like, yikes, it’s kind of scary.

Janice seems to have a different outlook about how these conditions impact her teaching, embracing the changes:

I'm enjoying it more...because you know, when you start encouraging them to ask the questions, they start asking some pretty darn good questions, and I like being able to have those kind of conversations with them.... It’s made me a lot less cranky, honestly, because it’s not so much of me wanting... class to be quiet and sit there silently while I'm telling them things and expecting them to write stuff down.... I like the challenge and so it makes it more a little [sic] interesting to me.

Finally, the changing landscape of required assessments is continually on the minds of science teachers. Samuel states that he feels that “of course, the big demand will be the assessment, state assessment that will be based on that [the NGSS]. Now, we have to prepare our students for that.” Samuel also discusses how the NGSS will affect the way in which science teachers are evaluated: “When they evaluate you, they’re going to be looking for those things [the SEP’s and CCC’s]. Those would be some of the demands that would be put on us as teachers.” Further, Ron expresses strongly held views of the political aspect of the NGSS reform:

To me, this is a political document, it’s one where, it’s like if we create a test with this, it will make sure that the teachers look like they have no idea what they’re doing because obviously, the kids all failed the test, so the teachers must be a bunch of idiots.

Summary

Efforts to implement the Next Generation Science Standards (NGSS) affect teachers in a number of ways. For some the standards place new demands on their teaching and planning styles. Practices and methods that have been employed for years may need to be changed or abandoned. Others feel the pressure of being accountable to new and unfamiliar expectations.
These factors can change the experience of teachers in both positive and negative ways. In contrast to a traditional, didactic approach to teaching science, the NGSS calls for more student-centered approaches that can alter the professional experiences of science teachers. The NGSS is structured so that teachers must attend not only to content knowledge but also to scientific and engineering practices (SEP’s) and crosscutting concepts (CCC’s). Together these comprise two of the three dimensions of the NGSS. These dimensions encourage teachers to use techniques in the classrooms that put students at the center of knowledge acquisition and meaning making. These teaching techniques may be unfamiliar to science teachers and cause them to change their roles in the classroom. This can be a source of stress for teachers, especially when combined with the prospect of their being evaluated on how well they meet these new and unfamiliar challenges. Not all teachers are as concerned, e.g., Janice, but others, such as Ron, seem to have a more cynical opinion of the political pressures behind a reform such as the NGSS.

**Needed Supports**

Most of the teachers who participated in this study discussed the need for support to help them effectively implement the Next Generation Science Standards (NGSS). The teachers felt that without the assistance of their schools and school districts, they would be unable to interpret the meaning of the standards, understand what curricular and instructional changes they call for, and find the time and instructional resources necessary to implement them. The needed supports mentioned by the teachers included ongoing administrative support, help understanding the standards, professional development, and a centralized science coordinator.

Janice expresses the importance of administrative support in terms of securing the time and instructional resources necessary to implement the standards: “Well, supports from administration, I think that goes back to … them giving us the time and … trying to help us
secure technology.” She also discusses a need for administrators to provide support to teachers when dealing with parents who might not understand the changes that the NGSS may bring to their children’s classrooms:

I think [with] some parents … some support from the district that there’s going to be some change in the curriculum and just … kind of stand behind it … as we make the changes. But I mean, I don't know if there’s going to be much backlash or [if] parents might appreciate that their kids are doing something more interesting than just sitting and taking notes, you know.

Samuel captures the sentiment expressed by most of the teachers: “The most important thing I’d like to say is in the implementation process there’s nothing that is more important than providing staff support, staff development.” Samuel makes the point that providing administrative support to teachers is crucial for guidance in the implementation process:

So it is absolutely critical that when you set [a] goal like … NGSS, you don’t just set [sic] goal, but you have to take the teachers by their hands and walk them through, encourage them, continue to provide support so that it is not like … something that you're doing that is a mystery.

Teachers in this study mention the need for help in understanding the various aspects of the Next Generation Science Standards (NGSS). Kyle expresses this saying:

… we need to have an understanding of the standards …..there needs to be an understanding of how to read standards and understanding of what they’re asking for, understanding of what each of the different, you know, pillars of the next gen standards need and are looking for.

Samuel briefly recalls early efforts in his district to help teachers understand the standards with a meeting that was organized by his district’s then science coordinator:

The first thing we did was … sit down and actually delve into the standards. Look at the performance expectations; look at what is it that you’re not supposed to cross, that’s the upper border; look at the science, engineering and practices, the disciplinary core … ideas, the crosscutting ideas.

Katherine emphasizes the importance of district support to help teachers understand how the NGSS are structured and what demands they place on teachers:
But the supports that we provide teachers are really important in terms of helping them understand what are [sic] the SEPs [science and engineering practices]…. And what is NGSS asking of us … it’s a very dense document and [they] … are written in a very different way than our previous standards. So, even just helping educators understand how to think about structure, talk about [and] organize around the standards and understand them, that’s the first big challenge.

Troy agrees that the NGSS are a difficult document to read and thinks that teachers need some help deconstructing the standards and expressing them in a simpler form:

I think we need some … good documents that somebody has kind of broken down a little bit to make it a little more readable. A lot of these standards, as you read from the top to the bottom… they’re pretty convoluted…. So, having somebody … that is working with it on a regular basis and has broken it down a little bit would be helpful.

Katherine explains that since teachers and school districts are in the early stages of implementation it is difficult to know just what supports teachers will need:

… I think we’re on the learning curve right now in terms of what teachers are going to need. And I don’t know … I’ve worked for a couple of different districts in the state, and I’m in communication with the other districts … and I think no one is a hundred percent like, “Wow, we have NGSS nailed now…” Everybody is still really learning what this work is going to be. And so, the supports are in different stages right now…. And so, I don’t know that we’d even know what supports we need yet. That’s what I’m trying to say.

In regard to needed supports and resources, most of the teachers in this study expressed the idea that professional development was key to helping teachers understand and implement the standards. Troy relates that professional development is especially needed to help teachers make the connections between disciplines that the NGSS calls for:

That is professional development; we’re going to need a lot of it. Because I think [for] some people, science is … one of those fields where it’s not a hierarchal deal, where if you teach math, that it builds on itself and you start with … Algebra 1, Geometry, Geometry 2, Precal, Cal. You know, science is chemistry, biology, physics. And for a lot of people, there’s not that crossover. It’s really hard. Some people love physics and they don’t care about biology, [or] they don’t care about physics…. So, to get that crossover piece in this and the engineering piece of that ... is going to take some good professional development to help us.
Little of this type of professional development in regard to implementing the NGSS has occurred up to this point in most participants’ school districts. What has occurred appears to have involved mainly groups of science teachers meeting to discuss the NGSS, with some guidance. Janice recalls one such meeting:

We had a couple of meetings to bring them [science teachers] all together and to explain to them what the new standards look like, how to read them, how to understand them, what it really means to implement it [sic] to the classroom, trying to make them un-scary, because it looks very scary.

Kyle teaches in the same district as Janice. He provides details about one meeting that occurred in their school district:

We’ve had … a gal from the ESD came in to two different groups. And in [sic] top of reading this and helping us kind of work our way through them and navigate. She also gave us ideas of what that would look like, and things she’s seen in other classrooms. And then we’ve also had some training in just as [sic] blanket area of project-based learning, not specifically towards science or NGSS….

Katherine has a leadership role within her district, although she is not officially a science coordinator. She discusses her vision for professional development around the NGSS, which would have teachers engaged in an active way:

I would probably do that in a way that we have teachers actually, not talk about doing this, but do it, like duplicate some of the SEPs [science and engineering practices] with teachers. So, they’re running experiments, asking questions and observing their own learning process while they’re doing it, and seeing how is that different than the way we would have done it without NGSS as a guide. Let’s think about that. Let’s actually practice, move our bodies, move us through it as educators.

Janice supports professional development that occurs outside the regular school day and year:

“I’d probably do it like a summer institute…. four or five days together just to kind of hammering [sic] it out, at least for the first semester.” Katherine feels that professional development should not be limited to centralized efforts, but should also occur at the school level:
Well, I think professional development that’s effective is … job embedded. Yes, we can provide global workshops for people, but that’s probably not going to be as effective as smaller groups of teachers working in the building…. So, let’s get our heads together and figure out what we need to who’s doing that well.

Samuel shares his opinion, gained from his earlier experience with his district’s professional development, that professional development is not just about analyzing the standards; it is also a way to build confidence within teachers:

Once they go through the process and understand what is expected of them … anxiety levels go down, and the demands that it feels [sic], usually perception, perception, you know, changes over time. I, as a teacher before … we went for that … staff development, I also felt the same way…. So, the staff development is not always to give information to teachers. It is also to stop them, to slow down so they can see what’s there for them.…

Some of the teachers in this study discussed the need for coordination of their implementation efforts. Troy relates how the work of implementing the NGSS will need to be a collaborative effort that has its roots at the district level:

I think we need a collaborative effort not only within our own school and people that teach certain subjects but cross-curricular subjects. How can chemistry help biology, biology help chemistry? So, some collegiality is definitely going to be needed in that. But also, we have to expand that out to a district … what are other people doing that could help … and be willing to share so that everybody … is coming along not just one group or another? And then, that means that we need coordination…. So, we need somebody probably at the district level working on that, helping to coordinate that.

Samuel agrees on the need for someone to coordinate the efforts of the teachers in the implementation process:

I will probably recommend … science coordination…. [A] science coordinator who is hands-on … in every district, like we had before…. Because … that person then oversees the development of a knowledge base that is going to be there that people can build on and learn from over time…. We did that in this district. But for some reason … they’ve dismantled that, and we will come back and say, “Geez, what did we do to ourselves? Where did we throw all the stuff that we created?” And we need to reassess that and go back to that approach where we have somebody central … who we can depend on…. This is the person that is going to bring us together as a science people.
Samuel relates that because of staff changes at the district level, in regard to curriculum coordinators, there had been a regression in the efforts to implement the NGSS:

…a lot of these things have been lost, but that education that we’ve [sic] got was important to our understanding of what’s coming. Now, these people who brought all the knowledge … they’re in different things now, so we are on our own, but had that not happened, I wouldn’t be sitting down here and having an intelligent conversation with you about NGSS.

Summary

According to the participants in this study, implementation of the Next Generation Science Standards (NGSS) will require the support of school and district administrators. Teachers need guidance in understanding the facets of the NGSS and how to teach them. Professional development, both at the school and district level, where teachers are working together in conjunction with district science coordinators, is necessary to help teachers understand the scope and meaning of the NGSS and what they mean for their instructional methods. Collaboration between science teachers is also needed so that teachers can collectively create strategies to implement the NGSS in their classrooms.

Summary

Most of the teachers in this study seem to have a limited understanding of the various facets of the NGSS, focusing mainly on familiar content standards and largely overlooking or misunderstanding the scientific practices and crosscutting concepts that comprise two of the three dimension of the NGSS. This gap in their understanding led some of the teachers to conclude that they were already addressing the requirements of the NGSS.

Teachers may be reluctant to change their teaching to accommodate the NGSS because they feel that the standards are not right for their students, or because they are close to retirement and do not want to make any major changes to their teaching or curricula. Additionally, some of
this study’s participating science teachers expressed their reluctance to devote the time and energy required to learn the standards and adopt new methodologies because of a fear that their efforts would be wasted if educational policies change, once again.

The importance of context is seen in that the importance that school and district leaders communicated to science teachers about the Next Generation Science Standards (NGSS) had a large influence on the extent of implementation efforts at their schools. Where there was a sense of importance displayed by school leaders, implementation efforts were more pronounced. If school leaders did not convey a sense of importance around the NGSS, the teachers did not place a high value on implementation efforts.

The teachers in this study expressed a desire and need for support from school and district leaders in the areas of securing resources and professional development. It takes time to develop an understanding of the various aspects of the Next Generation Science Standards (NGSS), adapt curricula, and learn new teaching techniques. Science teachers also need time for collaboration with other science teachers and professional development that specifically addresses the features of the NGSS and provides training for employing them in classrooms.
CHAPTER FIVE
CONCLUSIONS

Introduction

The purpose of this study was to explore the challenges faced by Washington State high school science teachers in regard to implementing the Next Generation Science Standards (NGSS) in their classrooms. Seven high school science teachers from five high schools in Eastern Washington were interviewed using phenomenological interview techniques. They were asked questions relating to how the NGSS was affecting their teaching, what challenges they faced when attempting to implement the NGSS, and what resources they needed to accomplish the task of implementation. As presented in chapter four, four themes emerged through analysis of the interview data: (a) impediments to implementation, (b) the contextual nature of implementation, (c) impact of implementation on teachers, and (d) needed supports for implementation. As the literature reviewed in chapter two indicates, this is apparently one of the first studies to explore high school teachers’ perceptions of the challenges they face in implementing the NGSS in their classrooms. It is therefore hoped that the findings of this study will provide guidance to school and district leaders in their efforts to implement the NGSS in their schools.

Based on the thematic findings presented in chapter four, four overall conclusions of the study can be stated:

1. The Next Generation Science Standards (NGSS) are a complex reform policy for science education that are difficult for science teachers to understand and implement. Analysis of the data in this study suggests that science teachers do not have a thorough understanding of the NGSS. This is reflected in the comments of some of the science teachers that participated in this
study who seem to have a narrow interpretation of the standards, focusing mainly on the content standards without much consideration of the practices and crosscutting concepts. Contributing to the general lack of understanding of the NGSS, most of the teachers participating in this study had not closely examined the NGSS, apparently because the administrators and leaders in their schools have not signaled that it was important to do so. The first priority, therefore, for a state that has adopted the NGSS is to focus on building a general understanding of the standards among both school district administrators and science teachers.

2. This study reveals that there are multiple impediments to full implementation of the Next Generation Science Standards (NGSS) that need to be addressed. In addition to the weak understanding of the standards by teachers, impediments include teacher reluctance to alter their teaching practices, concerns about a return on their implementation efforts, and a lack of resources needed to accomplish the task.

The teachers in this study revealed that some are reluctant to modify their curricula and teaching methods because they do not feel that the standards are appropriate or because they are close to retirement. Many of them have seen educational policies that were enacted in the past that did not last. They are concerned that the effort that they expend now making changes will have been wasted if and when the policies of the NGSS fade as well.

A major obstacle to implementation is a lack of resources for teachers; especially time, to complete the work necessary. Because of the complexity of the NGSS, substantial amounts of time are needed for teachers to work collaboratively, exploring the standards and developing curricula and new methods to use in their classrooms. In addition, the pedagogy and changes promoted by the NGSS places additional planning burden on teachers, for which no additional
time is provided during the school day. Time must be found for science teachers to collaborate, develop and modify curriculum, and plan their lessons.

3. Substantial professional development is needed to help administrators and teachers understand the Next Generation Science Standards (NGSS) and to learn new methods to employ in science classrooms. In light of the demands that science teachers face everyday in the performance of their work, it is not realistic to expect that they will be able to deeply explore the various aspects of the NGSS, and reevaluate their practice on their own. The science and engineering practices (SEPs) represent a shift in the way science has been taught, and training is required to learn how to employ them in the classroom. The crosscutting concepts (CCCs) draw attention to themes that span the different fields and disciplines of science and engineering. Since many science teachers tend to have expertise in a particular area of science, such as biology or physics, many will need additional education to understand how these concepts apply in areas outside their specialties.

4. School and district administrative support is needed to provide the resources and help create a culture that values the efforts of teachers in meeting the challenges they face implementing the Next Generation Science Standards (NGSS). The degree to which science teachers spend time thinking about the NGSS and how they affect their practices is considerably influenced by the importance placed on them by school and district administrators. When principals and district administrators signal the importance and value of the NGSS, science teachers are more inclined to act towards implementing them. Teachers need tools in the form of print material and access to technology to perform the tasks embedded in the NGSS. Administrative support is needed to acquire and maintain these resources. Only school and district administrators can provide the rationale, time, professional development, and
instructional resources that are needed to implement the NGSS and make them a regular part of science education. Realizing the vision of the NGSS requires that school leaders act to ensure that science teachers are prepared to meet the challenge.

**Implications of this Study**

Some of the implications of this study are fairly obvious. The conclusions related to the complexity of the Next Generation Science Standards (NGSS) and the need for professional development has implications for both state policy and local district practice. If Washington State is going to adopt a policy as complex and far reaching as the Next Generation Science Standards (NGSS), it needs to support the policies implementation. This means that the state legislature needs to allocate funding for the development and conduct of professional development across the state. The professional development that is to be provided to teachers needs to be specific and targeted to the NGSS. Its development will require a cooperative effort involving the Washington State Office of Superintendent of Public Instruction (OSPI), educational service districts (ESDs), school districts, state colleges and universities, and other organizations that have expertise in science education and professional development, such as the National Science Teachers Association (NSTA), the American Modeling Teachers Association (AMTA), and others. This will be a major effort that will require substantial time and commitment. It should begin immediately. While this study did not interview any school administrators, the fact that the teachers interviewed did not express that their principals had communicated any sense of urgency about the NGSS, suggests the possibility that the principals share the teachers’ lack of understanding of the NGSS and would benefit from some professional development themselves.
Another implication of this study’s conclusions related to professional development includes the state making additional funding available to provide the professional development to teachers. To be effective, the professional development for the NGSS needs to be substantial, meaning that it needs to occur outside of the regular school schedule and be of a sufficient duration for science teachers to not only come to an understanding of the NGSS but to experience it and learn ways to apply them. This will require the use of facilities and instructional material as well as hiring providers and providing additional pay for teachers who participate. To ensure that this actually occurs, the state legislature should include this funding in the education budget so that already tight district budgets do not have to absorb the costs. In addition, local districts need to provide on-going support for teachers and the time for teachers to collaborate around the Next Generation Science Standards (NGSS). Teachers need time set aside on a regular basis to work together to plan instructional strategies and to reflect on the efficacy of their lessons. This collaboration time needs to occur frequently and be of sufficient duration so that instructional strategies can be analyzed and the lessons learned can be applied immediately to their classrooms.

The conclusions regarding impediments to implementation and school and district support have implications for school districts and educational service districts (ESDs) creating and maintaining a science coordinator position. There is a need for oversight and coordination of the efforts of science teachers at different schools. This local person would provide on-going and targeted support to science teachers, helping them understand the standards and providing them information and resources about effective practices. The science coordinator is the person who organizes the professional development and maintains a library of resources that are available to science teachers to use in their planning and practice. A centralized person is needed to evaluate
progress of the implementation of the Next Generation Science Standards (NGSS) and identify resources to make it more effective. This is a critical position for long-term and uniform implementation of the NGSS and, as Samuel, a participant in this study, states “is the person that is going to bring us together as a science people.”

This is a very limited study of the perspectives of science teachers in an urban and suburban region of eastern Washington State. There are several questions that this study does not address where further research is needed. One such question would examine the challenges faced by science teachers in implementing the Next Generation Science Standards (NGSS) in small, rural school districts. Rural school districts deal with many issues that larger school districts do not. Studies of how science teachers deal with these issues when implementing the NGSS are needed. Sixteen states, including Washington, have adopted the NGSS as their state science standards. Comparative studies are needed to explore the ways other states have dealt with the issues raised in this study. How do they provide professional development to their administrators and teachers? What monetary and other resources have they devoted to implementation efforts? What impediments and struggles do they face? These are some of the questions that need to be answered by conducting further research.

Reflections

As I discussed in chapter one, my interest in conducting this study stems from my experience as a high school physics teacher and, more specifically, my experience as a Modeler. As such, I am very supportive of the Next Generation Science Standards (NGSS) dimensions of the crosscutting concepts (CCCs) and especially the science and engineering practices (SEPs). It has been my experience during my career that most science teachers pay more attention to presenting the facts about scientific concepts and focus less on having their student’s process and
understand the underlying structure and connections between ideas. This is very understandable in an environment where there is a lot of content to “cover” in a limited time. We tend to teach in the way we ourselves were taught, and the practice of “present, practice, and test” has been going on in our schools for a long time. The NGSS seeks to change that. I also know from my experience that change of this nature does not come easily or naturally to many teachers. I have seen my student teachers, for example, struggle to lead a class discussion that tries to get students to describe the meaning of the shape of a graph, or to explain the evidentiary basis for a claim their students are making. Adapting the principles of the NGSS is going to be difficult for teachers.

I am somewhat discouraged to learn through the conduct of this study just how little time schools and science teachers are thinking about the Next Generation Science Standards (NGSS). Apparently, since any state assessment keyed to the NGSS is still several years into the future, the NGSS are not a priority for administrators and science teachers. Having witnessed and experienced myself the challenges of modifying one’s teaching style and philosophy, I know that true implementation of the NGSS is an endeavor that will take years to accomplish. My fear is that our schools and teachers will not begin the task until we are forced to, and the result will be the kind of fragmented and spotty implementation, focusing only on content standards that may appear on an exam, that I have seen in the past. The true vision of the NGSS will not be realized if this happens and it is likely to fall by the wayside, as have so many other educational initiatives in the past.

Still, there is reason for hope. The teachers I interviewed for this study were, to a person, intelligent, well-meaning teachers whose main concern was doing what is best for their students. If provided the rationale and resources these teachers will embrace many of the tenets of the
Next Generation Science Standards (NGSS). Even if they are not fully implemented, I believe
the NGSS will have any overall positive effect on science teaching and on student achievement.
REFERENCES


http://www.nextgenscience.org/development-overview

Achieve, Inc. (2014). *Standards background: Research and reports*. Retrieved from:

http://www.nextgenscience.org/standards-background-research-and-reports


http://www.issuelab.org/resource/delicate_balance_district_policies_and_classroom_practices


doi:10.1002/(SICI)1098-2736(199610)33:8<821::AID-TEA1>3.0.CO;2-Y


Communication and community outreach: Dorn adopts new science standards. Retrieved from:

https://www.k12.wa.us/Communications/PressReleases2013/NewScienceStandards.aspx


http://www2.ed.gov/policy/elsec/leg/esea02/index.html


APPENDIX A

Interview Guide

1. Tell be about your education and how you came to be a high school science teacher.
   • How long have you been an educator?
   • What kind of work did you do before you became an educator?
   • What attracted you to education?

2. Tell me about your working environment, including your school and district, and the community they are in.
   • What do you think your school/district/communities priorities are for education?
   • Do you feel as if the school/district/community is supportive of its teachers?
   • What kind of support does your school and district supply?
   • In what ways is sufficient or lacking?

3. Tell me about your general approach to teaching science, i.e., your “teaching philosophy” or your basic approach to classroom teaching?

4. Thinking about the NGSS, is that impacting your approach, i.e., playing any role in how you teach?

5. Tell me about the demands or challenges that the Next Generation Science Standards (NGSS) place on your practice and how you are dealing with them.

6. Ideally, what resources, supports, or help should be in place to support implementing the NGSS, that is, to help teachers actually use the standards in their classrooms?

7. Is there anything else that you would like to tell me that I did not ask or that you feel would be useful to this study?