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The purpose for conducting this qualitative study was to explore best practices of exemplary standards-based science programs and instructional leadership practices in a charter high school and in a traditional high school. The focus of this study included how twelve participants aligned practices to *National Science Education Standards* to describe their science programs and science instructional practices. This study used a multi-site case study qualitative design. Data were obtained through a review of literature, interviews, observations, review of educational documents, and researcher's notes collected in a field log. The methodology used was a multi-site case study because of the potential, through cross analysis, for providing greater explanation of the findings in the study (Merriam, 1988).

This study discovered six characteristics about the two high school's science programs that enhance the literature found in the *National Science Education Standards*; (a) Culture of expectations for learning-In exemplary science programs teachers are familiar with a wide range of curricula. They have the ability to examine critically and select activities to use with their students to promote the understanding of science; (b) Culture of varied experiences-In exemplary science programs students are provided different paths to learning, which help students, take in information and make sense of concepts and skills that are set forth by the standards; (c) Culture of continuous feedback–In

exemplary science programs teachers and students work together to engage students in ongoing assessments of their work and that of others as prescribed in the standards; (d) Culture of Observations-In exemplary science programs students, teachers, and principals reflect on classroom instructional practices; teachers receive ongoing evaluations about their teaching and apply feedback towards improving practices as outlined in the standards; (e) Culture of continuous learning-In exemplary science programs teachers value continuous personal development, teachers are provided on-going science professional development opportunities to improve instructional practices, teachers reflect and share professional practices, and teachers establish professional learning communities within their classrooms; and (f) Culture of shared leadership-In exemplary science programs instructional leadership purposes and values are consistently shared among all stakeholders which are outlined in the standards.

These results are potentially useful for understanding exemplary standards-based science programs and science instructional leadership practices as a model for science programs trying to improve science education so that all students can have a true scientific learning experience.

A STUDY OF SCIENCE LEADERSHIP AND SCIENCE STANDARDS IN EXEMPLARY STANDARDS-BASED SCIENCE PROGRAMS

by

Wendy Renae Carpenter

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Approved by

Carl Lashley
Committee Chair

APPROVAL PAGE

This dissertation, written by Wendy Renae Carpenter, has been approved by the following committee of the Faculty of The Graduate School at The University of North Carolina at Greensboro.

Committee Chair Carl Lashley

Committee Members Rick Reitzug

Ann Davis

Leila Villaverde

Date of Acceptance by Committee

Date of Final Oral Examination

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CHAPTER I

INTRODUCTION

Many headlines flood the media and point to current and future issues that students will face as adults. Some of these issues include "*The World's Most Magnificent Animals Face New Threats of Extinction," "More of the Mysteries of Saturn Discovered," "Scientists Detail and Make Predictions About Climate Changes,"* and *"Journal Reports Advancements in Technology and Medicine"* (Hammerman, 2008, p. 1). Hammerman (2008) states that "understanding such issues requires knowledge of scientific concepts and principles and their relationships to technology and society" (p. 1).

Since the passing of the *No Child Left Behind Act* (NCLB) of 2001, America's schools have struggled to increase the quality of science education for all students. The initial NCLB accountability policies focused on math and English. As a result, this led to a reduction of the emphasis and time devoted to science instruction, especially in elementary schools (Saka, 2007). In many schools, instructional time allocated to science was left completely to the discretion of teachers. At other schools, teachers only focused on NCLB accountability subjects, especially in the last several months preceding testing (Lee & Luykx, 2005). According to DeBoer (2002), "the states' emphasis on testing led individual states to focus on standards" (p. 413). The focus of state standards in science has largely been in preparation for the *No Child Left Behind* (NCLB) science mandate that went into effect in 2007–2008.

This Act made these content standards a mandatory part of the federal and state accountability systems in which annual tests in science were administered in Grades 5, 8, and Biology. Due to these strong mandates, students are now expected to demonstrate excellence in science. Although these mandates have been implemented, the teaching practices and instructional leadership roles in science still need to be addressed. In President Obama's 2011 State of the Union speech, he contended that "the quality of our math and science education [still] lags behind many other nations" (para. 34).

It has been nearly 20 years since a new vision and guide for reform in science education appeared in the form of national standards. However with this "abundance of resources in the standards, the science society appeared equipped and prepared to make major improvements in science education. But it has been a slow process due to the lack of clarity on how to use the standards" (Keely, 2005, p. xi).

Studies of the impact of standards on science education and student outcomes tend to approach the ways students encounter learning. A small group of studies looked at the historical, professional, political and economic influences of the science standards movement in the United States (DeBoer, 2006; Kahle, 2008; Osborne, Erduran, & Simon, 2004). A second considerably larger set of studies focus on the impact science policies had on curriculum, instruction, and the equitable treatment of all students (DeBoer, 2006; Lynch, 2000) and a third set of studies examined the status of K–12 science teaching in the United States (Banilower, Heck, & Weiss, 2007; Bybee & Kennedy, 2005).

Only a relative handful of case studies (DeBoer, 2006; Kennedy, Long, & Caminos, 2009; Taylor, 2009) have specifically examined the gap between standards and practices. Even though the science community has learned much from implementing the standards and from these practices, there is still a need to understand learning and teaching in exemplary science programs as well as the expectations of science leaders that can inform a “revision of the standards and revitalize science education” (National Research Council [NRC], 2012, p. ix).

The limited information on the educational benefits of understanding the implementation and structural components of these programs is regrettable because it is this sort of evidence the science education community appears to be requiring if it is to support a scientific and technological world. This study attempted to draw upon the current knowledge base on exemplary science programs for high school science teachers addressing the need for greater focus on standards, leadership, and research in how students learn and are able to think scientifically.

The History of Improving Science Education

The determination to improve science education in the United States began over fifty years ago with the launching of Sputnik in 1957. Several publications, including: *A Nation at Risk* (National Commission on Excellence in

Education [NCEE], 1983), *Science for All Americans* (American Association for the Advancement of Science, 1989), *Benchmarks for Science Literacy* (American Association for the Advancement of Science/Project 2061, 1993), *Trends in International Mathematics and Science Study* (U.S. Department of Education, 2003), *National Science Education Standards* (NSES; NRC, 1996), and *The Nation's Report Card* (U.S. Department of Education, 2005) indicate the U.S. is behind other nations in science and mathematics. *The Third International Mathematics and Science Study* (TIMSS; International Association for the Evaluation of Educational Achievement, 2003) indicates U.S. students are not taught with high expectations, and the high school curricula lacks continuity and complexity.

The American Association for the Advancement of Science (AAAS) founded Project 2061 in 1985; its publication, *Science for All Americans*, includes what all students should be able to do in science, mathematics, and technology. *Science for All Americans* became the foundation for the science standards movement of the 1990s and outlines science literacy and principles for effective teaching and learning. *Science for All Americans* highlights the relationships between the natural and social sciences, mathematics, and technology, and the knowledge, skills, and attitudes all students should retain (American Association for the Advancement of Science, 1989).

The Benchmarks for Science Literacy was published after *Science for All Americans* to provide guidelines for what all students should know and be able to do in science by the end of grades 2, 5, 8, and 12 (American Association for the Advancement of Science/Project 2061, 1993). Although these grades provide the foundation, the publication does not suggest a rigorous method for instruction. It is a guide that can be used to create curricula to meet students' needs and meet the goals of *Science for All Americans*.

In 1989, the National Governors Association approved setting national education goals. Several science education associations along with the U.S. Department of Education encouraged the NRC to play a leading role in the efforts to develop national standards for science education in content, teaching, and assessment. The *National Science Education Standards*, released in 1996, provide criteria to judge the quality of what students know and are able to do; the quality of the science education programs that provide the opportunity for students to learn science; the quality of science teaching; and the quality of the assessment practices and policies. The *NSES* provide the criteria to judge the progress toward a national vision of teaching and learning (NRC, 1996).

The Current Status of Science Education

A Nation at Risk (NCEE, 1983) examined public education and pushed the need for educational reform to the top of the political agenda. The belief that the achievement of U.S. students was falling behind other countries led to the standards based movement of accountability and high-stakes testing to evaluate the quality of instruction and learning (Amrein & Berliner, 2002; Baker & Foote, 2006). In 1998, the poor performance of U.S. secondary school students on the

TIMMS raised serious concerns about the state of education in the US. United States students scored well below the international average on the TIMMS for mathematics and science (U.S. Department of Education, 2003). The 2007 TIMMS for 8th grade mathematics and science scores place the United States below Singapore, Chinese Taipei, Japan, Republic of Korea, England, Hungary, Czech Republic, Slovenia, Hong Kong, and Russian Federation (National Center for Education Statistics, 2007). There was no detectable change in U.S. 4th graders' science achievement from 1995 to 2007 (National Center for Education Statistics, 2007).

Countries with high science achievement share common characteristics, which include: a vision of what all students in each grade should learn, with a focus on a few topics in depth both in textbooks and instruction; well prepared teachers who consult regularly with other teachers and other resources; and alignment between what is expected, taught, and tested (National Science Board, 1999). In its report, the National Science Board brought attention to the state of science and mathematics education in the US, and emphasized the need for world class achievement in science and mathematics education because it is critically important to our Nation's future (National Science Board, 1999).

Concerns led to the implementation of state and federal mandates intended to improve the education of disadvantaged students and accountability developed as a driving force to improve science education. One of the first national accountability efforts was the passage of the *Title 1 of the U.S.*

Elementary and Secondary Act of 1965 (U.S. Department of Education, 2004, public law 89-10), which was passed to ensure that all children have a fair and equal opportunity to obtain a quality education.

The passage of the *No Child Left Behind Act of 2001* (NCLB) (107th U.S. Congress, 2001) provided a comprehensive reauthorization of the *Elementary and Secondary Education Act of 1965*, which incorporates specific proposals for testing, accountability, parental choice, and early reading. *NCLB* authorized a number of federal programs aimed at improving the performance of primary and secondary schools. It mandated that states give students annual standardized tests and show improvement for all students to be proficient by 2014.

Researchers' Perspective on Science Education

According to *National Science Education Standards*, "Learning science is something that students do, not something that is done to them. In learning science, students describe objects and events, ask questions, acquire knowledge, construct explanations of natural phenomena, test those explanations in many different ways, and communicate their ideas to others" (NRC, 1996, p. 20). I experienced this type of learning while being educated in secondary public schools during the late 1980s. Science was my favorite subject and favorite class to attend. My biology teacher was my favorite teacher and role model. Ms. Shirley Streater's love and passion for biology was shared with her students each and every day. The development of scientific literacy to preparation for careers in science was the ultimate focus of her classes. I graduated with a Bachelors of Science Degree in Biology and also received a Master's Degree in Biology Education due to the phenomenal science exposure that she shared with her students. It was my promise to myself that I would also share this passion with my students and I did!

I pursued a career in administration after teaching science for 8 years. "It is awesome to have someone who understands science education finally apart of the administrative team," stated a science teacher (Personal Communication, 2006) during my first week on the job. As an administrator, I believed that "principals play a critical role in strengthening science programs by fostering a shared commitment to improving science learning outcomes, engaging with teachers, and supporting strong science professional development" (Umphrey, 2011, p. 23).

I am currently an Educational Consultant for North Carolina Department of Public Instruction (NCDPI). I work with educational leaders to improve teaching and learning in low performing schools across the state. Science education is my single most important responsibility. As I have traveled to these schools, I have often wondered why some of the science programs are working towards improving science education for all students while others are struggling. In spite of all the labels placed on the schools and even the students served in these schools, the schools are rich in scientific resources, highly qualified teachers, and principals. I have constantly been encountered with questions from teachers, principals, and district leaders about how other schools are improving their science programs and science data. Usually these stakeholders want me to provide answers with immediate “FIXES.”

I realized in my desire to continue to serve these schools and make an impactful difference in the field of science education, I needed to explore other science programs and science leadership. While I believe my own expertise and commitment must be used as an instrument for providing others with helpful science practices and science leadership techniques, it is powerful when the perspectives and observations of many are shared. Therefore, my professional inspiration was to explore their views and for them to share some of their beliefs in order to assist all science programs with improving science education more effectively.

Problem Statement

Our nation’s ability to remain competitive in a global market renews the urgency to improve Science Education in era of high-stakes testing. The crisis being confronted in science education in most American schools has prompted many academic organizations and institutions to develop standards that can serve as important guides in shaping the education system to be more science oriented. Years later after the standards were implemented, how have the science standards been translated into practice? What are the results for science educational leaders’ practices and student learning (NRC, 2002)?

Purpose of the Study

The purpose of this study was to explore standards and instructional leadership practices in exemplary science programs at two high schools, a charter high school and a traditional high school. This exploration used multi-site case study qualitative methodology. The framework developed by the *National Science Education Standards* for investigating the influence of national standards in science guides this study. The study was presented as a case study of practices. Because the content standards outline what students should know, understand, and be able to do, this study:

- Analyzed exemplary standards-based science programs,
- Analyzed science educational leaders' role in implementing exemplary standards-based science programs,
- Examined science leaders' perceptions of an exemplary standards-based science education program existence in schools.

Research Questions

This qualitative investigation assisted in understanding how science educators' enacted leadership in schools' exemplary science programs and how these practices were connected to standards identified in educational literature. Educational researchers must explore the gap between research and practice in order to provide another resource to move the science community forward. The over-arching research question for this study was: What impacts have science instructional leadership and science standards had on the success of exemplary standards-based science programs? To provide focus for this research, the following research questions were developed:

1. How is science leadership exhibited in a standards-based program?
2. How are instructional practices, curriculum, and professional development connected to science standards and supported in order to establish and achieve high expectations for students in science?
3. How does connecting assessments to science standards and evaluating standards-based science programs impact student learning?
4. Which standards are perceived by science educational leaders as most important to student learning in an exemplary science programs?

Definitions of Key Terms

1. Instructional Leadership in Science Education: Effective instructional leaders that are tensely involved in curricular and instructional issues that directly affect student achievement in science education (Cotton, 2003).
2. National Science Education Standards (NSES): The Standards present a vision of a scientifically literate population, and outline what students need to know, understand, and be able to do at different grade levels (NRC, 1996; Center for Science, Mathematics, and Engineering Education, 2009).

3. Standards: The term Standards refer collectively to national standards articulated in the *National Science Education Standards*. According to the National Science Education Standards,

> Standards are premised on a conviction that all students deserve and must have the opportunity to become scientifically literate. The Standards look toward a future in which all Americans, familiar with basic scientific ideas and processes, can have fuller and more productive lives. (NRC, 1996, p. ix)

For the purpose of this study, instructional leaders in science education are leaders that include: principals, assistant principals, science instructional coaches, and science teachers. These instructional leaders focus on assessments, standards, and data, attend on-going professional development, and collaborate daily. These instructional leaders also focus on curriculum and instructional practices that affect the achievement of all students in science.

Importance of the Study

This study provides detailed analysis of the characteristics of an exemplary standards-based science program and offers reflections on improving science programs. Such information could improve instructional educational practices by providing a model for science programs that could be used for improving science education in other schools. According to Merriam (1990), the case study is a suitable method for dealing with critical problems of practice and extending the knowledge base of various aspects of education.

This study is important because it examined instructional leadership practices in science education and the importance of standards in exemplary science education programs. Evidence of a connection between science leaders' actions and the success of science education was useful in helping to determine how science leaders prioritized their work and engaged in specific leadership practices that are connected to science standards.

Additionally, research showed that there were exemplary science programs that possessed and utilized the qualities exemplified by the *National Science Education Standards* (DeBoer, 2006; Kennedy et al., 2009; Taylor, 2009). What did these programs do that set them apart from other science programs? What influenced the science leaders to exhibit these exemplary qualities? With these questions in mind, this qualitative study of exemplary programs in a traditional high school setting and in a charter high school setting was undertaken using the *National Science Education Standards* as a framework. Tapping into the expertise within exemplary science programs clearly have the potential to benefit students, teachers, principals, and the science community.

Organization of the Dissertation

Chapter I provided an introduction and a rationale for this research study. It includes the pertinent information about the movement for science education, the current status of science education and the development of the *National Science Education Standards*. Chapter II explains the role of standards, instruction leadership in science education and research practices for science education programs. This chapter also includes the conceptual framework that guides this study. Chapter III describes the methods used to conduct this qualitative case study. Chapter IV includes background information describing the settings and an introduction of the participants and the results of the study. Chapter V presents the analysis with links to the literature and addresses the gaps and limitations in the study. It also includes a revision of the conceptual framework for the study, implications, and further research.

CHAPTER II

REVIEW OF LITERATURE

The focus of this study is to examine aspects of best practices and leadership practices in exemplary science programs as connected to *National Science Education Standards*. This chapter was designed to provide readers with background information on exemplary science programs and leadership. In this chapter, I will discuss the role of standards with an emphasis on the *National Science Education Standards*. The literature on the current research practices in science education will be discussed in the final section.

This chapter is composed of two distinct sections. In the first section, I will discuss research on the role of standards including an overview of the *National Science Education Standards*. This overview provides a description of the standards and how leaders exhibit these standards in exemplary science programs. The final section in this literature review is about science practices. I will focus on current research practices with an emphasis on exemplary science teaching practices and instructional leadership practices found in science education.

The Role of Standards

The NRC has leadership roles in the development of standards for science education. This framework includes recommendations for student outcomes in science as well as guidelines for science teachers (AAAS, 1993, 2001; NRC, 1996, 2002).

National Research Council

The *National Science Education Standards* were produced by the NRC in 1995 and published in 1996. Unlike other documents, the Standards deal concurrently with six aspects of science education:

- Standards for science teaching (instruction).
- Standards for professional development for teachers of science.
- Standards for assessment in science education.
- Standards for science content (curriculum).
- Standards for science education programs (evaluations).
- Standards for science leadership. (NRC, 1996, p. 3)

First, the science teaching standards describe what teachers of science at all grade levels should know and be able to do. They are divided into six areas:

- The planning of inquiry-based science programs.
- The actions taken to guide and facilitate student learning.
- The assessments made of teaching and student learning.
- The development of environments that enable students to learn science.
- The creation of communities of science learners.
- The planning and development of the school science program. (NRC, 1996, p. 4)

The Council of Chief State School Officers (2009) discussed in *Teaching Practices* that good science teaching should be standards-based and must incorporate the building on past experiences of the learner, taking more time for the learner to assimilate the concepts, and fostering the use of more inquiry into the curriculum. When discussing *The Authentic Best Practices of Science Teaching*, four pedagogical practices were noted to be truly best practice according to *How Students Learn: History, Mathematics, and Science in the Classroom* (NRC, 2005). The empirical evidence that supported this use was substantial:

- Engaging Resilient Preconceptions,
- Organizing Knowledge around Core Concepts,
- Supporting Metacognition and Student Self-Regulation, and
- Cooperative Learning.

Second, the standards movement raised many questions about how to structure training for teachers and professional development. In a study conducted by Mant, Wilson, and Coates (2007) more than 1,000 science teachers and academies from 50 countries identified two major reasons for the global decline in the level of interest in science:

- Difficulty finding, training and retaining well-qualified teachers, and
- Difficulty keeping up with emerging science and changing teaching practices.

Robert E. Yager (2005) argues in *Exemplary Science: Best Practices in Professional Development* that new visions for the continued education of teachers would be needed if any significant use of the Standards, any improvement of existing teachers, and any improved ways of preparing teachers were to be realized. Professional development standards were added into the *National Science Education Standards* as a way of ensuring that the science teaching standards would be central in the preparation of new teachers and the continuing education of all in-service teachers (NRC, 1996).

The professional development standards present a vision for the development of professional knowledge and skills among teachers. They focus on four areas:

- The learning of science content through inquiry.
- The integration of knowledge about science with knowledge about learning, pedagogy, and students.
- The development of the understanding and ability for lifelong learning.
- The coherence and integration of professional development programs. (NRC, 1996, pp. 4–5)

According to the *Standards* (1996), professional development activities need to be clearly and appropriately connected to teachers’ work in the context of the school. In this way, teachers gain the knowledge, understanding, and ability to implement the standards (NRC, 1996).

An argument was made about the lack of ongoing professional learning opportunities provided for school and district leaders in the large-scale National Science Foundation curriculum reform projects of the 1950s and 1960s (Elmore, 2000). Borko, Wolf, Simone, and Uchimaya (2003), McLaughlin and Mitra (2001), and Stein, Hubbard, and Mehan (2004) suggested a need for these opportunities as the potential explanation for the failure of research-based professional innovations to take root in school systems. The high-quality leadership development opportunities provided for district administrators, school principals, and teachers are lacking.

Smylie, Bennett, Konkol, and Fendt (2002) emphasize that principals who are involved in professional development and discussions with other principals reflect on their own progress and form the lens of an outside observer. Collegial interactions with members of the school community such as teachers, students, and other administrators enables principals to develop more powerful solutions to problems and integrate curriculum scaling data with school values (Murphy, 2002).

Next, quality assessment is an essential part of quality instruction. Assessment can be used to monitor student progress toward stated learning goals and to measure the effectiveness of instruction. In an era of public accountability, Kottler and Costa (2009) recommend that assessment instruments have enormous potential to pull curricula and instructional practices toward what is included in those assessments. The assessment standards provide criteria against which to judge the quality of assessment practices. They cover five areas:

- The consistency of assessments with the decisions they are designed to inform.
- The assessment of both achievement and opportunity to learn science.
- The match between the technical quality of the data collected and the consequences of the actions taken on the basis of those data.
- The fairness of assessment practices.
- The soundness of inferences made from assessments about student achievement and opportunity to learn (NRC, 1996, p. 5).

Assessments provide students with feedback on how well they are meeting expectations, teachers with feedback on how well their students are learning, school districts with feedback on the effectiveness of their teachers and programs. This feedback in turn guides the professional development of teachers and encourages students to improve their understanding of science (NRC, 1996). This is consistent with the recommendation from Kali, Linn, and Roseman (2008), “Assessment plays an important role in promoting consistency throughout the science education system by offering clear expectations to all participants and by providing feedback on how well those expectations are being met” (p. 180). Furthermore, assessment should be aligned with the same learning goals that the curriculum is organized to teach, so that entire system can function together to achieve the same goal.

In addition to content, professional development, and assessments, the science content standards outline what students should know, understand, and be able to do in the natural sciences over the course of K-12 education. They are divided into eight categories:

- Unifying concepts and processes in science.
- Science as inquiry.
- Physical science.
- Life science.
- Earth and space science.
- Science and technology.
- Science in personal and social perspective.
- History and nature of science. (NRC, 1996, p. 6)

Each content standard states that as a result of activities provided for all students in those grade levels, the content of the standard is to be understood or certain abilities are to be developed (NRC, 1996).

The science education program standards describe the conditions necessary for quality school science programs. They focus on six areas:

- The consistency of the science program with the other standards and across grade levels.
- The inclusion of all content standards in a variety of curricula that are developmentally appropriate, interesting, relevant to student's lives, organized around inquiry, and connected with other school subjects.
- The coordination of the science program with mathematics education.
- The provision of appropriate and sufficient resources to all students.
- The provision of equitable opportunities for all students to learn the standards.
- The development of communities that encourage, support, and sustain teachers. (NRC, 1996, p. 7)

Program standards deal with issues at the school and district level that relate to opportunities for students to learn and opportunities for teachers to teach science (NRC, 1996).

Finally, the science education system standards consist of criteria for judging the performance of the overall science education system. They consider seven areas:

- The congruency of policies that influence science education with the teaching, professional development, assessment, content, and program standards.
- The coordination of science education policies within and across agencies, institutions, and organizations.
- The continuity of science education policies over time.
- The provision of resources to support science education policies.
- The equity embodied in science education policies.
- The possible unanticipated effects of policies on science education.
- The responsibility of individuals to achieve the new vision of science education portrayed in the standards. (NRC, 1996, p. 8)

Schools are part of hierarchical systems that include school districts, state school systems, and the national education system. Although the school is the central institution for public education, all parts of the extended system have a responsibility for improving science literacy (NRC, 1996).

In the introduction of the *National Science Education Standards* (NRC, 1996), the answer to the question “Why *National Science Education Standards*?” (p. 12), it was emphasized that implementation of the *National Science Education Standards* would highlight and promote the best practices of these exemplary programs and give these programs the recognition and support they deserve. The *National Science Educational Standards* (NRC, 1996) reinforced the notion that “science education standards provide criteria to judge progress toward a national vision of learning and teaching science in a system that promotes excellence” (p. 12).

North Carolina Essential Standards

Since it has been nearly 20 years since the science education community have utilized new standards, standards such as *North Carolina Essential Standards* (North Carolina's Accountability and Curriculum Reform Effort [ACRE], 2008) and *Next Generation Science Standards* (Achieve Inc., 2013) were created and are based on many of the documents that helped to form the NRC (such as *National Science Education Standards*) and *American Association for the Advancement of Science*. States have written science standards or academic frameworks that can be found on their state department of education websites. They are frequently based on national standards as well as local concerns. Since 2010, North Carolina has implemented essential standards for education curriculum in all levels (K-12).

Studies postulate that *North Carolina Essential Standards* strive to preserve the value for local control of each school district to design particular curricular and instructional approaches that best convey the content to their students (ACRE, 2013). According to these standards, student engagement in inquiry-based instruction is critical in building a conceptual understanding of science content, which is critical for success in the 21st century. Moreover, *North Carolina Essential Science Standards* recommend science teachers to provide students with opportunities to engage in activities, which are exemplars of experimentation, scientific inquiry and technological design (ACRE, 2013).

North Carolina Science Essential Standards for high school level are built on individual subjects that include; Physical Science; Biology, Physics, Chemistry, and Earth Science (see Table 1). These standards were designed to focus on science content. However, these standards do not include the frameworks from the *National Science Education Standards* that focus not only on science content and assessment but emphasizes instruction, science teaching, professional development, leadership, programs, and systems which research previously showed are valuable for exemplary science programs.

Table 1

North Carolina Science Essential Standards for High School Level

Subject	Field/topic	Essential Standard(s)
Biology	Structure and Function of Living organisms	Understand the correlation between cell structures, cell functions and organelles. Examine the cell as a living system.
	Ecosystems	Analyze organisms' interdependence, and how human actions affect the environment.
	Genetics and Evolution	Understand how DNA (structure and function) determine traits. Understand the influence of the environment on genetic traits, and **/**or how relations of alleles affect genetic traits. Understand how DNA technology is applied. Explain the theory of evolution (natural selection). Examine how classification systems develop owing to speciation.
	Molecular biology	Understand the significance of biological molecules to living organisms. Examine the connection between energy use in a cell and biochemical processes.
Physics	Forces and Motion	Analyze the objects' motion based on the principal of conservation of energy, conservation of momentum and impulse. Analyze force systems and their interaction with matter.

Table 1

(Cont.)

Subject	Field/topic	Essential Standard(s)
Physics (cont.)	Energy: conservation and transfer	Analyze the behavior of waves, electric circuits and moving charges. Understand the concept of energy, work and power, and their relationships.
	Interactions of Energy and Matter	Explain the concepts of charges, magnet and electrostatic systems.
Physical science	Forces and Motion	Understand the correlation between forces and motion. Understand motion in terms of acceleration, velocity, speed, and momentum
	Matter: properties and change	Understand properties, structure and types of matter. Comprehend chemical interactions and bonding. Examine the rule of nucleus in radioactivity and radiation.
	Energy: Conservation and Transfer	Comprehend the nature of waves, energy transfer and conservation and types of energy. Understand magnetism, electricity and their relationship.
Earth Science	Earth in the universe	Explain the earth's role in space.
	Earth structure, processes and systems	Explain the effect of forces and processes on lithosphere, and how human influence affects the lithosphere. Explain various processes and structure in the lithosphere. Evaluate how people use water. Examine the patterns of global climate change. Explain the individual and collective effect of hydrosphere, lithosphere and atmosphere on the biosphere. Appraise human behaviors in terms of their ability to sustain survival on earth.
Chemistry	Matter: Change and Properties	Analyze the structure of ions and atoms. Understand the chemical and physical properties of atoms, and their position on Periodic table. Understand bonding (strength, type and properties).
	Energy: Transfer and conservation	Understand the relationship between temperature, pressure, volume and phase. Analyze chemical reactions in form of energy, product formation and quantities.
	Interactions of energy and matter	Comprehend the solutions and solution processes. Understand various variables affective the rate of chemical reaction and equilibrium.

Source: ACRE (2013)

***The Next Generation Science Standards* (NGSS)**

The next generation science standards (NGSS) is a multi-phase effort that is aimed at creating new standards rich in practice and content, organized in an articulate manner across grades and disciplines in order to provide learners (students) with a globally benchmarked science education (NRC, 2012). The NGSS are built on three dimensions of the NRC's Framework: practices, crosscutting concepts and disciplinary core ideas (Achieve, Inc., 2013).

The Framework identifies seven crosscutting concepts that bridge disciplinary boundaries, uniting core ideas throughout the fields of science and engineering. Their purpose is to help students deepen their understanding of the disciplinary core ideas, and develop a coherent and scientifically based view of the world. The seven crosscutting concepts of the Framework are as follows:

- Patterns.
- Cause and effect: Mechanism and Explanations.
- Scale, proportion, and quantity.
- Systems and system models.
- Energy and matter: Flows, cycles, and conservation.
- Structure and function.
- Stability and change.

The Framework identified a small number of disciplinary core ideas that all students should learn with increasing depth and sophistication, from Kindergarten through Grade 12. Key to the vision expressed in the Framework is for students to learn these disciplinary core ideas in the context of science and engineering practices (NRC, 2012).

Finally, the framework for the *Next Generation Science Standards* describes the progressions of disciplinary core ideas in the grade band endpoints. The progressions are summarized in the content that occurs at each grade band. Some of the sub-ideas within the disciplinary core ideas overlap significantly. Readers will notice there is not always a clear division between those ideas, so several progressions are divided among more than one sub-idea.

In order to harvest the benefits of *Next Generation Science Standards*, states, including North Carolina need to adopt them in wholly, and in every classroom. However, since the NGSS will not define a curriculum, assessments, and professional development, it is imperative for states to provide a more comprehensive guidance to classroom teachers and principals.

Nevertheless, science education today as it is perceived and practiced around the world is based on goals for science teaching that were established more than a century ago (see Table 2). The Next Generation Science Standards and North Carolina Essential Standards have not invented new goals, or ideas, but have reinvented the same wheel of science education that has been around for more than a century. The *National Science Education Standards* have been at the center of the science education reform movement in the United States and have supported the development of curricula and approaches in science instruction.

Table 2

Comparison of Present Standards to *National Science Education Standards*

The Role of Science Standards	National Science Education Standards (1996)	North Carolina Essential Standards (2010)	Next Generation Science Standards (2013)
	National Standards	State Standards	Consortium of Standards created by 26 States
Emphasis	Scientific Inquiry • Unifying Concept/Process • Include all students • Used by scientists • Used by engineers	Scientific Inquiry used by scientists and engineers and integrated into; • Physical Science • Biology • Earth Science • Inquiry used by scientists • Inquiry used by engineers	Science Practices • Inquiry used by scientists • Inquiry used by engineers
Emphasis	Science Content • Include all students • Physical Science • Life Science • Earth and Space Science • Technology • Social Perspective • History Perspective	Science Content • Built on individual subjects • Includes human evolution and climate change in Advanced Placement Courses only	Science Crosscutting Concepts: • Human Evolution • Human role in climate change • Cause/Effect • Patterns • Energy/Matter • Structure/Function
	Science Instruction • What the teacher does • What the student does	Science Instruction • Student Learning • Essential Ideas	Science Disciplinary Core Ideas • Essential Ideas
	Science Assessments • Created by students • Created by • teachers • Aligned to Standards	Science Assessments • Aligned to Standards	Science Assessments: Not Available (Refer to National Science Education Standards-1996)
	Science Evaluations • Critiqued by all stakeholders	Science Evaluations: Not Available(Refer to National Science Education Standards-1996)	Science Evaluations: Not Available(Refer to National Science Education Standards-1996)
	Science Programs • Inquiry Science Base	Science Programs: Not Available(Refer to National Science Education Standards-1996)	Science Programs: Not Available(Refer to National Science Education Standards-1996)

Table 2

(Cont.)

The Role of Science Standards	National Science Education Standards (1996)	North Carolina Essential Standards (2010)	Next Generation Science Standards (2013)
	National Standards	State Standards	Consortium of Standards created by 26 States
Emphasis	Science Professional Development • For teachers • For principals	Not Available(Refer to National Science Education Standards-1996)	Not Available(Refer to National Science Education Standards-1996)
	Science Leadership • Shared leadership	Not Available(Refer to National Science Education Standards-1996)	Not Available(Refer to National Science Education Standards-1996)

Summary

Science programs that address the full range of science standards and connect learning to students' lives and their communities enable them to recognize and appreciate the significance of their learning, which better prepares them to think critically and act responsibly as citizens (Hammerman, 2008). Quality science education is based on standards that are rich in content and practice, and have aligned curricula, pedagogy, assessment, teacher preparation, and professional development. What educators have learned concerning these indicators in science education are outlined in the *National Science Education Standards.* This study builds on the strong foundation of this document that sought to identify and describe the major ideas in science education.

Research Practices for Science Education Programs

Effective science instruction in schools is necessary to not only ensure a greener future but also to attain excellent scientific literacy for all generations (House of Lords, 2006). The federal government sees the importance of science education in the United States. In the statements of astronaut and ex-senator John Glenn (2000), math and science instruction is a critical factor in sustaining the country's edge in the global economy. Implementation of the Standards will require a sustained, long-term commitment to change. The following practices in science education can assist schools in using the standards. These practices should give a quality head-start for schools embarking upon the journey of improving science programs

Curriculum

From the framework of the *National Science Education Standards*, the NSTA (2003) recommends that in the area of science curriculum, science leaders must:

- Develop and align curriculum, assessment, and instruction with national and state standards while meeting local needs.
- Ensure the development and/or selection of science curriculum that is pedagogically appropriate and encompasses strategies for building conceptual understanding.
- Ensure the development and/or selection of standards-based science curriculum that infuses inquiry, promotes scientific concepts and processes, and integrates content to ensure understanding in Earth and space sciences, biology, chemistry, and physics.
- Collaborate with post-secondary educators to ensure quality content in the preK-12 curriculum. (p. 2)

The NRC (1996, 2002) further presents Science Content as Supported by the Standards (see Table 3).

Table 3

Standards-Supported Changes in Content Standards

Changing Emphasis	
Less Emphasis On	More Emphasis On
(1) Knowing scientific facts and information.	(1) Understanding scientific concepts and developing abilities of inquiry.
(2) Studying subject matter disciplines (physical, life, earth sciences) for their own sake.	(2) Learning subject matter disciplines in the context of inquiry, technology, science in personal and social perspectives and history and nature of science.
(3) Separating science knowledge and science process.	(3) Integrating all aspects of science content.
(4) Covering many science topics.	(4) Studying a few fundamental science concepts.
(5) Implementing inquiry as a set of processes.	(5) Implementing inquiry as instructional strategies, abilities, and ideas to be learned.

Source: NRC (1996, 2000, p. 113).

Instruction

From the framework of the *National Science Education Standards*, the NSTA (2003) emphasizes that in the area of science teaching and learning, science leaders must:

- Ensure that scientific inquiry and the development of science process skills, such as problem solving, are essential components of instruction and are integrated with content delivery.
- Encourage the use of variety of teaching styles that emphasize constructivist approaches, including differentiated instruction and cooperative learning.
- Encourage the use of student self-assessment in the classroom.
- Regularly communicate progress in student learning to parents and students.
- Build principals' capacities to recognize standards-based science instruction and to provide instructional leadership in science. (pp. 1–2)

NRC (1996, 2002) further presents Science Instruction as Supported by the Standards (see Table 4).

Table 4

Standards-Supported Changes in Science Instruction

Less Emphasis on	More Emphasis on
(1) Treating all students alike and responding to the group as a whole	(1) Understanding and responding to individual students' interests, strengths, experiences, and needs
(2) Rigidly following curriculum	(2) Selecting and adapting curriculum
(3) Focusing on student acquisition of information	(3) Focusing on student understanding and use of scientific knowledge and inquiry processes
(4) Presenting scientific knowledge through lecture, text, and demonstration	(4) Guiding students in active and extended scientific inquiry
(5) Asking for recitation of acquired knowledge	(5) Providing opportunities for scientific discussion and debate among students
(6) Testing students for factual information at the end of the chapter	(6) Continuously assessing student understanding
(7) Maintaining responsibility and authority	(7) Sharing responsibility for learning with students

Table 4

(Cont.)

Less Emphasis on	More Emphasis on
(8) Supporting competition	(8) Supporting a classroom community with cooperation, shared responsibility, and respect
(9) Working alone	(9) Working with other teachers to enhance the science program

Source: NRC (1996, 2000, p. 52).

Assessment

Using the *National Science Education Standards* as a framework, in the area of assessment, the National Science Teachers Association (2003) supports using the standards by suggesting that science leaders must:

- Implement assessment methods aligned with desired student outcomes.
- Ensure the use of a variety of qualitative and quantitative assessments for school improvement, instructional improvement, and enhanced student learning.
- Provide support for the development and use of assessments that address the needs of diverse learners and that support understanding of science content and processes.
- Promote teacher use of assessment data to inform instructional practice. (p. 2)

The *National Science Education Standards'* framework further supports assessment standards by reiterating that

> assessment standards provide criteria to judge progress toward the science education vision of scientific literacy for all. The standards describe the quality of assessment practices used by teachers, state, and

> federal agencies to measure student achievement and the opportunity provided students to learn science. (NRC, 1996, p. 75)

By identifying essential characteristics of exemplary assessment practices, the standards serve as guides for developing assessment tasks, practices, and policies. These standards can be applied equally to the assessment of students, teachers, and programs; to summative and formative assessment practices; and to classroom assessments as well as large-scale, external assessments (NRC, 1996). NRC (1996, 2002) Presents Assessment of Science as Supported by the Standards (see Table 5).

Table 5

Standards-Supported Changes in Assessment

Changing Emphasis	
Less Emphasis On	More Emphasis On
(1) Assessing what is easily measured.	(1) Assessing what is most highly valued.
(2) Assessing discrete knowledge.	(2) Assessing rich, well-structured knowledge.
(3) Assessing scientific knowledge.	(3) Assessing scientific understanding and reasoning.
(4) Assessing to learn what students do not know.	(4) Assessing to learn what students do understand.
(5) Assessing only achievement.	(5) Assessing achievement and opportunity to learn.
(6) End of term assessments by teachers.	(6) Students engaged in ongoing assessment of their work and that of others.

Table 5

(Cont.)

Changing Emphasis	
Less Emphasis On	More Emphasis On
(7) Development of external assessments by measurement experts alone.	(7) Teachers involved in the development of external assessments.

Source: NRC (1996, 2000, p. 100).

Evaluation

According to the *National Science Education Standards, "*the science education system standards provide criteria for judging the performance of the components of the science education system responsible for providing schools with necessary financial and intellectual resources" (NRC, 1996, p. 227). All elements of the K-12 science program must be consistent with the other *National Science Education Standards* and with one another and developed within and across grade levels to meet a clearly stated set of goals:

- In an effective science program, a set of clear goals and expectations for students must be used to guide the design, implementation, and assessment of all elements of the science program.
- Curriculum frameworks should be used to guide the selection and development of units and courses of study.
- Teaching practices need to be consistent with the goals and curriculum frameworks.
- Assessment policies and practices should be aligned with the goals, student expectations, and curriculum frameworks.
- Support systems and formal and informal expectations of teachers must be aligned with the goals, student expectations and curriculum frameworks.

- Responsibility needs to be clearly defined for determining, supporting, maintaining, and upgrading all elements of the science program. (NRC, 1996, p. 210)

The program standards are criteria for the quality of and conditions for school science programs. They focus on issues at the school and district levels that relate to opportunities for students to learn and opportunities for teachers to teach science. NRC (1996, 2002) Presents Program Standards as Supported by the Standards (see Table 6).

Table 6

Standards-Supported Changes in Science Programs

Changing Emphases	
Less Emphasis On	More Emphasis On
(1) Developing science programs at different grade levels independently of one another	(1) Coordinating the development of the K-12 science program across grade levels
(2) Using assessments unrelated to curriculum and teaching	(2) Aligning curriculum, teaching, and assessment
(3) Maintaining current resources allocations for books	(3) Allocating resources necessary for hands-on inquiry teaching aligned with the Standards
(4) Textbook-and lecture-driven curriculum	(4) Curriculum that supports the Standards and includes a variety of components, such as laboratories emphasizing inquiry and field trips.
(5) Broad coverage of unconnected factual information	(5) Curriculum that includes natural phenomena and science-related social issues that students encounter in everyday life.

Table 6

(Cont.)

Changing Emphases	
Less Emphasis On	More Emphasis On
(6) Treating science as a subject isolated from other school subjects	(6) Connecting science to other school subjects, such as mathematics and social studies.
(7) Science learning opportunities that favor one group of students	(7) Providing challenging opportunities for all students to learn science.
(8) Limiting hiring decisions to the administration	(8) Involving successful teachers of science in the hiring process.
(9) Maintaining the isolation of teachers	(9) Treating teachers as professionals whose work requires opportunities for continual learning and networking.
(10) Supporting competition	(10) Promoting collegiality among teachers as a team to improve the school.
(11) Teachers as followers	(11) Teachers as decision makers.

Source: NRC (1996, 2000, p. 224).

Professional Development

Using the *National Science Education Standards* as a framework, in the area of professional development, the National Science Teacher Association (2003) supports using the standards by suggesting that science leaders must:

- Facilitate regular teacher meetings designed to improve science instruction at both the building and district levels.
- Actively involve teachers in the decision making for professional development programs, curriculum changes, and other activities that affect their practice.
- Use disaggregated student achievement data and teacher evaluation processes to drive instructional improvement and to plan professional

development at the individual, school, and district levels that are rich in science content and model best practices.

- Promote collaboration and partnership among district and state policy makers and universities to develop licensure requirements and ensure effective recruitment, induction, and retention of the science teaching workforce.
- Provide appropriate mentoring relationships for new teachers. (p. 2)

NRC (1996, 2002) Presents Professional Development as Supported by the Standards (see Table 7).

Table 7

Standards-Supported Changes in Professional Development

Changing Emphasis	
Less Emphasis On	More Emphasis On
(1) Transmission of teaching knowledge and skills by lectures.	(1) Inquiry into teaching and learning.
(2) Learning science by lecture and reading.	(2) Learning science through investigation and inquiry.
(3) Separation of science and teaching knowledge.	(3) Integration of science and teaching knowledge.
(4) Separation of theory and practice.	(4) Integration of theory and practice in school settings.
(5) Individual learning.	(5) Collegial and collaborative learning.
(6) Fragmented, one shot sessions.	(6) Long-term coherent plans.
(7) Courses and workshops.	(7) A variety of professional development activities.
(8) Reliance on external expertise.	(8) Mix of internal and external expertise.
(9) Staff developers as educators.	(9) Staff developers as facilitators, consultants, and planners.

Table 7

(Cont.)

Changing Emphasis	
Less Emphasis On	More Emphasis On
(10) Teacher as technician.	(10) Teacher as intellectual, reflective practitioner.
(11) Teacher as consumer of knowledge about teaching.	(11) Teacher as producer of knowledge about teaching.
(12) Teacher as follower.	(12) Teacher as leader
(13) Teacher as an individual based in a classroom.	(13) Teacher as a member of a collegial professional community.
(14) Teacher as target of change.	(14) Teacher as source and facilitator of change.

Source: NRC (1996, 2000, p. 72).

The *National Science Education Standards'* framework further supports professional development by reiterating that the *"Standards* present a vision of teaching and learning science in which all students have the opportunity to become scientifically literate" (NRC, 1996, p. 55). In this vision, teachers of science are professionals responsible for their own professional development and for the maintenance of the teaching profession. The standards provide criteria for making judgments about the quality of the professional development opportunities that teachers of science will need to implement the *National Science Education Standards* (NRC, 1996).

Leadership

In a study conducted by Gerard, Bowyer, and Linn (2008), the need for principal leadership in science teaching was emphasized. The premise of the study is based on the fact that principal leadership is essential in the implementation of instruction. According to Gerard et al. (2008), “effective principals can (a) successfully manage curriculum content and organization, (b) identify the effective use of resources, and (c) determine the role of curricular innovations within the school community” (p. 12).

In the first key area of principal leadership, the school leader basically guides the school community, especially the faculty, in the scope of curriculum innovation in the field of science (Gerard et al., 2008). Next, the principal can manage resources for the implementation of science curricula including professional development and fundamental technology systems (Gerard et al., 2008). Lastly, the principal can manage to build an incentive and rewards program to motivate faculties and students in teaching and learning science subjects (Gerard et al., 2008). Studies have shown that schools that have incentive programs in science subjects, such as scholarships and awards, are more likely to be successful in implementing science curriculum innovation (Linn, Davis, & Bell, 2004).

According to the NSTA (2003), “science leaders must cultivate a leadership network consisting of principals, lead teachers, science department heads, and community leaders to implement science education reform at all levels of the school system" (p. 1). The *National Science Education Standards* also recommends changing emphases from "teacher as follower" toward "teacher as leader" and from "teacher as target of change" toward "teacher as source and facilitator of change" (NRC, 1996, p. 72). This expanded concept of the leadership role for teachers includes recognizing the potential for teachers to be legitimate generators of knowledge. Science Program Standard E declared that "schools must work as communities that encourage, support, and sustain teachers as they implement an effective science program . . . an effective leadership structure that includes teachers must be in place" (NRC, 1996, p. 222). The implications are that teachers should be centrally involved as leaders in shifting science instruction toward standards-based science practices.

Instructional Leadership in Science Education

Educational leaders such as district superintendents and principals typically do not consider instructional leadership and in particular; knowledge of content important to their role as administrators. In *Teachers' learning communities: Catalysts for change or a new infrastructure for the status quo?* Wood (2007) discussed that most administrators and teachers play limited roles in sustaining instructional reform. This is due in part to the fact that there is typically little reward and often considerable risk for administrators and teachers that associate themselves with reform. Elmore in *Building a new Structure for School Leadership* (2000) and and Fink and Resnick in *Developing Principals as Instructional Leaders* (2001) also emphasize that professional isolation and a workday consumed by solving immediate problems prevent administrators, principals and teachers from reflecting on ways to improve curricula and instruction.

In his article “Teacher Leader,” Barth (2001) argues that there is growing evidence that principals and teacher leaders are indeed effective and perhaps essential allies in leading school wide improvements in teacher effectiveness and student learning. The NRC (1996) discusses the need for science education in order to implement standards-based curricula that demand high student performance. These standards see that there are significant roles of science educational leaders in strengthening science education in the schools. There are a few studies regarding administrators’ positions on science teachers’ knowledge, skills, and dispositions and a few studies discuss science leaders’ role in the delivery of science education (Lewthwaite, 2004; Spillane, Diamond, Walker, Halverson, & Jita, 2001).

Nonetheless, this is the reason that science education has been a topic of concern for so long. The widespread push for educational improvement has included calls for rigorous and focused content coverage in science. According to Elmore (2000), improvements in instructional quality and student outcomes are “possible with dramatic changes in the way public schools define and practice leadership” (p. 2).

The Impact of Principal Instructional Leadership

The term instructional leader can be defined in various was, but Reeves (2006) agreed "that an instructional leader uses specific knowledge, abilities, and behaviors to provide guidance to fellow faculty that improves the quality of instruction and student learning in a school or school district" (p. 130). In Blasé and Blasé's (1999) study on *Principals' Instructional Leadership and Teacher Development: Teachers' Perspectives*, they note by exercising their role as instructional leaders, principals can frame and articulate school goals, provide instructional supervision, and protect teachers' instructional time. They further emphasized that instructional leadership behaviors are known to be related to teacher commitment and professional involvement and exert an influence on teachers' instructional practices (Spillane, Halverson, & Diamond, 2004). Purkey and Smith (1983) point out that effective schools—schools in which teachers are able to devote time to the core curriculum in ways that enhance student learning—are characterized by school principals that act as instructional leaders with a presence of an agreement regarding the school's educational goals.

The Impact of Teacher Leadership

While science leadership is needed at every level within school systems, teacher leaders bridge the policy and political gaps by connecting students with effective instruction (Rhoton & McLean, 2008). Many examples in the professional literature advocate for teacher leaders as key figures in improving instruction (Lambert, 2003; Lieberman & Miller, 2004; Little, 2003; Murphy, 2002). School leadership needs to be broad-based and include the specialized knowledge of teachers, alongside that of administrators. This collaborative approach and purposeful application of different knowledge sets is central to school success. There is mounting evidence that student achievement is tightly linked to the working habits of the adults in the school (Marks & Pinty, 2003). Schools with strong professional learning communities, groups of teachers and administrators that take collective responsibility for student learning and work together toward a clear and commonly shared purpose, are effective in promoting student achievement (DuFour & Eaker, 1998; Hord, 1997).

The need for strong leadership in science education is critical. In this time of increased accountability, the principal's role as leader of school improvement is more important and more visible than ever before. Teacher leadership is an important ingredient for supporting this collaborative work among teachers that is necessary to achieve that success. According to the NRC (1996),

> Good educational leaders of science create environments in which they and their students work together as active learners. They have continually expanding theoretical and practical knowledge about science, learning, and science teaching. They use assessments of students and of their own teaching to plan and conduct their teaching. They build strong, sustained relationships with students that are grounded in their knowledge of students' similarities and differences. And they are active as members of science-learning communities. (p. 4)

Exemplary Science Programs

Merriam Webster's Online Dictionary (2005) defines exemplar as "something that serves as a model or an example" and exemplary means “serving as a pattern” (p. 434). When students were asked to define an exemplary science teacher in an article titled *What makes an exemplary teacher of science? The pupils’ perspective* (2011), responses suggest that exemplary teachers whose lessons pupils find interesting and look forward to teach lessons that are characterized by:

- Teachers who are clear explainers;
- Thinking and problem solving;
- Discussion;
- Less teacher demonstration and more practical work by pupils themselves; and
- contextualized science (Wilson & Mant, 2011, p. 124)

In general, the findings from the pupil responses also provide support for previous work on exemplary teaching by Wellington (2005), in which the ten accounts of exemplary science teaching covers a wide range of areas and teaching approaches and whereas these teachers are distinct from others teachers based on the involvement of their students in “learning science,” “learning about science,” and “learning to do science” (p. 313). There is also resonance with the findings of Smith (2011) that discusses the three core features of exemplary teaching which are the use of differentiated instruction, open inquiry and investigation, and the integration of science, technology, society, and the environment. Smith further discusses how at the heart of these three features is one fundamental theme: reflecting students in the curriculum. To take it a step further, students should be the curriculum.

There is considerable resonance here with the findings of The *National Science Education Standards* (NRC, 1996) which further describe program standards as an

> educational system in which all students demonstrate high levels of performance, in which teachers are empowered to make the decisions essential for effective learning, in which interlocking communities of teachers and students are focused on learning science, and in which supportive educational programs and systems nurture achievement. (p. 2)

According to criteria set by the Standards (NRC, 1996) an exemplary program must give students access to appropriate and sufficient resources, including quality teachers, time, materials and equipment, adequate and safe space, and the community; require access to the world beyond the classroom; content must be embedded in a variety of curriculum patterns that are developmental appropriate, interesting, and relevant to students' lives; teachers encouraged to discuss, reflect, and conduct research around science education reform; and effective leadership structures that includes teachers must be in place. These program standards focus on opportunities for students to learn and opportunities for teachers to teach science.

In the vision of science education portrayed by the Standards (NRC, 1996), effective teachers of science create an environment in which they and students work together as active learners. Students can acquire ideas, inquire skills, and have positive attitudes toward science. Students are challenged to accept and share responsibility for their own learning. Teachers make it clear that each student must take responsibility of his or her work. Teachers guide students in self-assessment and use student data, observations of teaching and interactions with colleagues to reflect on and improve teaching practice.

Teachers who meet the criteria of an exemplary teacher as set by the Standards (NRC, 1996) are experts in the subjects that they teach. They have a vast amount of content knowledge (Alsop, Bencze, & Pedretti, 2005; Tobin & Frasier, 1990). These teachers do not rely on textbooks. As stated in the Standards (NRC, 1996), these teachers extend the classroom beyond the world of the class. They help to make connections to students' lived experiences.

Teachers select science content and adapt and design curricula to meet the interest, knowledge, understanding, abilities, and experiences of students (NRC, 1996). Students develop academically in many different ways. Exemplary teachers differentiate instruction in order to meet the diverse needs of students (Tobin & Fraser, 1990).

In a 2006 investigation, *The Influence of Science Standards and Regulation on Science Teacher Quality and Curriculum Renewal*, Warren Beasley reported on a study of reviewing exemplary teaching practices. These teachers structured flexible and innovative learning experiences for individuals and groups, constructed intellectually challenging learning experiences, constructed relevant learning experiences that connected with the world beyond school, assessed and reported on student learning, contributed to professional teams, and committed to professional practice. This study identified the growth of teacher expertise in developing school science programs consistent with the *National Science Education Standards* framework documents. This occurred because the standards were the cornerstone of the teachers' careers and goals for ongoing professional development initiatives and also the standards reflected the day to day work of the teachers.

In summary, it is well documented in the literature relative to the teaching of science that exemplary teachers make it possible for students to learn in a safe and engaging environment, construct their own knowledge, take ownership of their own learning, and are required to think like a scientist (Alsop et al., 2005; Beasley, 2006; Standards, 1996; Tobin & Fraser, 1990; Wellington, 2005). Teachers conduct hands-on activities that tap into the different learning styles for all students, extend learning outside of the school, create collaborative environments with students and other teachers of science, seek ongoing professional learning, and are a part of the leadership team (NRC, 1996; Smith, 2011; Wilson & Mant, 2011). By documenting evidence of teacher characteristics in exemplary programs, these researchers believe the Standards would be valuable for future research as criteria for the quality of and conditions for school science programs.

Conceptual Framework

The conceptual framework for this study is drawn from the six standards of the *National Science Education Standards*. The six standards will be used to frame this investigation on how teachers are using the standards to improve teaching and learning.

- Standards for science teaching; in what ways do teachers plan appropriate instruction, use a variety of instructional methods, integrate and utilize technology, and help students develop critical thinking and problem solving skills?
- Standards for professional development for teachers of science; in what ways do teachers analyze student learning, link professional growth, and function effectively in a complex, dynamic environment?
- Standards for assessment in science education; how do teachers and students use a variety of assessment methods and communicate effectively?
- Standards for science content; how do teachers align their instruction with the standards and demonstrate knowledge of the course content, recognize the interconnectedness of content areas/disciplines, and make instruction relevant for students?
- Standards for science education programs; how do teachers provide a positive environment and nurturing relationships with students?
- Standards for leadership in science education; how do teachers lead in their classroom, school, and profession, advocate for schools and students, help students work in teams and develop leadership opportunities, and demonstrate high ethical standards?

The rationale for asking these questions lies in the expectation that all teachers will demonstrate these standards effectively in exemplary science programs. This study investigates the impact of the standards in exemplary science programs. Although these standards are grounded in the research for best practices, will the standards be useful in guiding teachers to become exemplary experts?

Every student and every teacher in the world should be exposed to exemplary science teachers that work in exemplary science programs.
Tobin and Fraser (1990), Alsop et al. (2005), Wellington (2005), and Beasley (2006) identified necessary criteria required for expertise in teaching science. Additionally, science teachers have the *National Science Education Standards*, which are anchored in the research of best practices and offer the opportunity for all science teachers and science programs to reach capacity in science education. The existing research of best practices for exemplary science teaching supports the six standards in the *NSES* as the conceptual framework for this study (see Figure 1).

Summary

This study acknowledges that several national documents identified the need for science education reform including; the *National Science Education Standards* (NRC, 1996). With the publication of the *NSES* (NRC, 1996) and science education research, we know what is required to be an exemplary science teacher. However a gap exists in our knowledge of understanding of what is required to establish exemplary science programs. This study does not try to analyze the reasons for our failings in science education, nor does it try to resolve them. Rather, it offers a perspective on the science education initiative that school districts can use as they attempt to understand what takes place in exemplary science programs and what should take place. Implementation of standards-based instruction has been identified in previous research as having a positive impact on student learning and attitudes toward science.

Figure 1. The six standards as outlined in the *National Science Education Standards* (NRC, 1996).

CHAPTER III

METHODOLOGY

Introduction

This chapter presents the rationale for using a qualitative research design within a case study perspective to explore standards and instructional leadership practices in exemplary standards-based science programs. Bridging the gap between research and practice and providing a resource to move the science community forward initiated this study. The specific components of this research study; including participant selection, a background description of the settings, data collection process, and data analysis are discussed. The trustworthiness of the research is also addressed.

Research Questions

This study examined exemplary standards-based science programs. This study investigated how the science standards were translated into practice in two high schools by addressing: leadership, professional development, instruction, curriculum, assessment, and evaluation. The over-arching research question for this study was: What impacts have science leadership and science standards had on the success of exemplary standards-based science programs? To provide focus for this research, the following research questions were developed:

1. How is science leadership exhibited in a standards-based program?
2. How are instructional practices, curriculum, and professional development aligned to science standards and supported in order to establish and achieve high expectations for students in science?
3. How does aligning assessments to science standards and evaluating standards-based science programs impact student learning?
4. Which standards are perceived by science educational leaders as most critical for an exemplary science program?

Rationale for a Case Study

This research has been designed to utilize the multi-site case study model. The reason for selecting the multi-site case study model was that this model is an empirical inquiry method in which a contemporary phenomenon within its real-life context is investigated. In a case study, the boundaries between the phenomenon and the context are not clearly evident, and multiple sources of evident are used (Yin, 2013). Case studies can either be single or multiple cases. This case study is particularistic, focusing on a particular situation, event, program or phenomenon. This specificity of focus makes it an especially good design for practical problems-for questions, situations, or puzzling occurrences arising from everyday practice (Merriam, 1988). The object of the study is to build a case study report (Yin, 2013).

The intent of case study research is a detailed examination of one setting, one subject, one depository of documents, or one particular event (Merriam, 1988). The general design of a case study is best represented by a funnel. The start of the study is the wide end. Good questions that organize qualitative studies are not too specific. The researcher scouts for possible places and people who might be the subjects or the sources of data; finds the location they think they want to study; and then casts a wide net, trying to judge the feasibility of the site or data source for her purposes. The multi-site case study approach includes in-depth interviewing, continual and on-going participant observation of a situation, study of documents, and keeping an observational log. By attempting to capture the whole picture, the study may reveal how people describe and construct their world.

Role of the Researcher

Related to the integrity of the qualitative researcher is a strategy sometimes labeled researcher's position, or more recently, reflexivity, "the process of reflecting critically on the self as researcher, the human as instrument" (Lincoln & Guba, 1985, p. 183). Researchers need to explain their biases, dispositions, and assumptions regarding the research to be undertaken. This clarification will allow readers to better understand how I have arrived at the particular interpretation of the data. As Maxwell (2005) explains,

> The reason for making perspective, biases, and assumptions clear to the reader is not to eliminate variance between researchers in values and expectations they bring to the study, but with understanding how values and expectations influenced the conduct and conclusions of the study. (p. 108)

As the researcher it is my goal to disclose what I believed about exemplary science programs and my role as a Secondary Science Instructional Coach with the North Carolina Department of Public Instruction. By doing this, I believed I was in a better position to approach the topic openly and honestly. This acknowledgement, along with member checks of the data, email exchanges with participants, and my research journal helped to filter my own experiences.

These efforts helped me be aware of the potential judgments that occurred during data collection and analysis based on my belief system instead of the actual data collected from participants. Writing out what I believed before I conducted the study gave me a frame of reference. I kept a journal with note cards during the time I collected data. I believed this helped me keep an open mind, differentiate between my thoughts and the participants' thoughts, and understand my own lens of viewing the world. Reading and rereading the data to find participants recurring words and phrases helped keep the focus on what the data revealed without prejudice or bias.

Researcher Identity

Teacher

The prior experiences that are relevant to my research of understanding how science leadership practices and science standards impact the *National Science Education Standards* in high school exemplary science programs come from my experience as a science teacher for 8 years, assistant principal for 3 years, and grades 6-12 Science Instructional Coach with the North Carolina

Department of Public Instruction for the last six years. I have a B.S. and M.A.Ed. in Biology Education. I also have a M.S.A. in school administration and a Specialist in Education degree (Ed.S).

I have taught in rural and urban high schools, low and high wealth high schools, traditional, charter, and private high schools and schools with various racial percentages. At the college level, I have taught General Biology and General Biology Laboratory. I have also served as a mentor for beginning science teachers.

I provided professional development for science teaching, which emphasizes cooperative learning, hands-on activities, laboratories, and relevance for student engagement. I served as a science committee chair on school improvement teams and science school chair. I also serve on Comprehensive Needs Assessment committees for NCDPI, to evaluate the strengths and areas to improve low performing school in North Carolina. These experiences provided opportunities for leadership and professional growth.

Assistant Principal and Instructional Coach

For the last nine years of my educational career, I have served as an assistant principal and as a science instructional coach. As an assistant principal, I worked with teachers, especially science teachers on implementing best practices to improve teaching and learning. In my present role as a High School Science Instructional Coach, I assist science teachers with their practice. My task is to help teachers reach capacity by providing strategies and resources for teaching and learning. I provide professional development to teachers and principals within the district which emphasizes cooperative learning, hands-on activities, laboratories, and relevance for student engagement. I also observe science classroom instructional practices in order to provide feedback and suggestions in order to improve science programs in the schools that I serve.

Researcher's Experiences of Meeting the Standards

My assumptions and experiences are supportive of the *National Science Education Standards*. My career spans enough time that I can reflect on my experiences for each standard. I believe each standard is grounded in best practices and research. I experienced each of these standards through my own inquiry and professional development. From my review of the literature, personal, as well as professional experience, I believe the *National Science Education Standards* are accurate description of the characteristics of exemplary science programs. In my role as a Secondary Science Instructional Coach with the North Carolina Department of Public Instruction, I have had professional develop opportunities, which have helped deepen my understanding of the *National Science Education Standards*. Part of my work involves assisting science teachers with utilizing each of the standards.

Researcher's Theoretical Perspective as a Science Educator

As a science educator I try to take into account my own way of learning when I teach students and coach science teachers. I learn better when I am discovering or actively doing science and I feel that most students learn better this way as well. The National Science Education Standards (NRC, 1996) places great emphasis on the need for students to be active learners, to inquire and be curious about science, and to communicate their understandings to others. Simply telling students what scientists have discovered, for example, is not sufficient to support change in their existing preconceptions about important scientific thinking. Similarly, simply asking students to follow the steps of the scientific method is not sufficient to help them develop the knowledge, skills, and attitudes that will enable them to understand what it means to do science and participate in a larger scientific community.

Rather than being passive recipients of large amounts of relatively disconnected information, I believe that students should be asked to make their own connections between what they are learning and what they have experienced in real life. It is particularly important that students in science classes move away from a conception of knowledge as something received from a teacher to something actively sought; from the concept of science as a long list of facts to be memorized to an active process that brings with it an understanding of the world and how it works. The overall theory underlying my thinking is the active learning theory or the discovery learning theory. I agree with Bonwell and Eison (1991) who believe that the learner in the active learner theory is an active participant in the process of learning rather than an empty vessel to be filled by the instructor. Discovery methods all involve some form of active participation on the part of the learner. Discovery learning is more meaningful to the student than information simply received from the teacher. When the student is actively involved in problem solving, the connections made and the organization imposed are based on the students' own prior knowledge rather than the teachers'. Because the connections are the students', they are already more meaningful than an artificially imposed connection.

How do teachers in exemplary science programs work together to maintain these successful programs as aligned to *National Science Education Standards*? My own experiences, assumptions, and goals shaped my decision to choose this topic. I am not convinced that it is reasonable to expect inexperienced science teachers and inexperienced science programs to have the same competence as veteran science teachers and veteran science programs that have had more time to understand the complexities of teaching application of these standards. Would the different groups of teachers and science programs have similar or dissimilar views and experience using the *National Science Education Standards*?

My experiences as a teacher, administrator, and instructional coach enabled me to draw conclusions about the success and needs of the *National Science Education Standards*, which may help our teachers reach capacity and achieve the vision of teaching and learning as portrayed in exemplary science programs.

Bounding the Study

A multi-site case study of exemplary standards-based science programs located in one charter high school and in one traditional high school was used to describe best practices in exemplary standards-based science programs. Data collection activities included interviews with science teachers, administrators, and a science coach; classroom observations; and document analysis. The two high schools were chosen because two science teachers; one from each school within the science departments are recipients of the Presidential Awards for Excellence in Mathematics and Science Teaching.

Selection of Participants

In some situations the use of purposive sample is chosen as the form of data collection (Yin, 2013). In the current study, the purposive sample provided the means to investigate exemplary science programs in North Carolina. Voluntary participation was sought from science leaders in these two schools designated to have exemplary science programs. Email addresses or contact information was obtained from the high schools' web pages. All science teachers within the science departments were contacted through email to participate in this study. No one was purposefully included or excluded from the study. This information is pertinent to understanding the data. Both high schools were conveniently located near several state of the art colleges and universities and the renowned University Park. The schools are identified as Honor Schools of Excellence by the North Carolina State Department of Public Instruction. As a result of the schools' proximity to higher education and research facilities, the communities boast one of the highest educated populations in America.

Jefferson High School was a state of the art traditional high school with a projected 95% of students continuing their education at the college and university level. Jefferson High School has 1,818.00 students, 1.0 principal, 3.0 assistant principals, 12.0 science teachers, 1.0 technology specialist, 1.0 student achievement coach, and 7.0 guidance counselors. Four science teachers, the district science coach, and one assistant principal agreed to participate in this study. A majority (89.7%) of the students were proficient in Biology during the 2011-2012 school year.

Douglas Charter High School was a charter high school that challenged college-bound students in a creative and supportive atmosphere to become knowledgeable, thoughtful, contributing citizens. Students were involved in the many resources of the community; the government, performing arts, social services, and the international community. Douglas Charter High School had 542.00 students, 1.0 principal, 1.0 academic dean, 8.0 science teachers, 3.0 curricular assistance, 1.0 technology specialist, and 3.0 guidance counselors. Five science teachers and the principal agreed to participate in this study. Ninety-five percent of the students were proficient in Biology during the 2011–2012 school year.

Science Data

Douglas Charter High School and Jefferson High School were chosen based on two reasons. Both schools had excellent academic performances. Each year, schools in North Carolina receive several designations based on their performance on the state's accountability (ABC's) exams. These designations are awarded on the basis of the percentage of students performing at grade level and on whether students have learned much as they are expected to learn in one year. The designations are defined as follows:

- Honor School of Excellence: At least 90% of students' scores are at or above Achievement Level III and the school makes or exceed its expected growth goal. Additionally, the school has met all of its Annual Measurable Objective (AMOs) targets.

- School of Excellence: At least 90% of students' scores are at or above achievement Level III and the school make or exceeds expected growth goal.

- School of Distinction: 80-90% of students' scores are at or above achievement Level III and school make or exceed its expected growth goal.

- School of Progress: 60-79% of students' scores are at or above achievement Level III and school make or exceed its expected growth goal.

- School Receiving No Recognition: School fails to reach its expected growth goals but has at least 60% of its students performing at or above achievement Level III.

- Priority School: School has less than 60% of its students' scores at or above achievement Level III, irrespective of making its expected growth status, and is not identified as a Low-Performing School.

- Low-Performing School: School fails to reach its expected growth goal and has significantly less than 50% of its students performing at or above achievement Level III.
- High Growth: School made expected growth & at least 60% of the students achieved their growth expectations.
- Expected Growth: School makes expected growth goal.

During the 2011–2012 school year, Douglas Charter High School and Jefferson High School received "Honor School of Excellence, School of Distinction" recognition. At least 80% of students scored at or above achievement Level III in both schools and made or exceeded expected growth. The schools met all AMO targets. Jefferson High School met 21 out of 21 targets and Douglas Charter High School met 10 out of 10 targets.

Nearly 90% of the students in Jefferson High School scored at or above grade level in Biology in comparison to the district's average of 75.4% and the state's average of 83.0%. Ninety-five percent of the students in Douglas Charter High School scored at or above grade level in Biology in comparison to the state's average of 83.0%.

Presidential Awards for Excellence in Mathematics and Science Teaching

The two high schools were also chosen because one science teacher received The Presidential Awards for Excellence in Mathematics and Science Teaching (PAEMST) from each of the schools. As the need to improve science education in the United States became a national priority, the *National Science Teacher Association* funded a search for excellence in science teaching. The search began in the 1980s, and over the next decade three prominent science educators, Penick and Bonnstetter (1993) and Yager (2000) reported their findings in science education journals and the PAEMST program, established by Congress in 1983, authorized the President to bestow up to 108 awards each year to math and science teachers that developed expertise in these areas.

PAEMST is the highest honor bestowed by the United States government specifically for K-12 mathematics and science teaching. The award recognizes those teachers who develop and implement a high-quality instructional program that is informed by content knowledge and enhance student learning. National efforts to reform science programs provide guidelines that call for science programs to connect; curriculum, instruction, assessment, evaluation, professional development, and leadership practices to science standards to improve student learning (Hammerman, 2008; NRC, 1996). The teachers are evaluated using the *Five Dimensions of Outstanding Teaching*.

Interconnectedness of the Presidential Awards in Excellence for Mathematics and Science Teaching and the *National Science Education Standards*

The NSTA Search for Excellence in Science Teaching, *NSES*, PAEMST are separate but interconnected documents (see Figure 2). The following review of these documents weaves together a description of an exemplary science programs. Being an exemplary science teacher is complex and multidimensional as reviewed in the literature. The standards are in place for all science teachers to use. These standards provide clear expectations for teachers to help improve teaching and learning. How they are being interpreted and used science teachers is the purpose of this research.

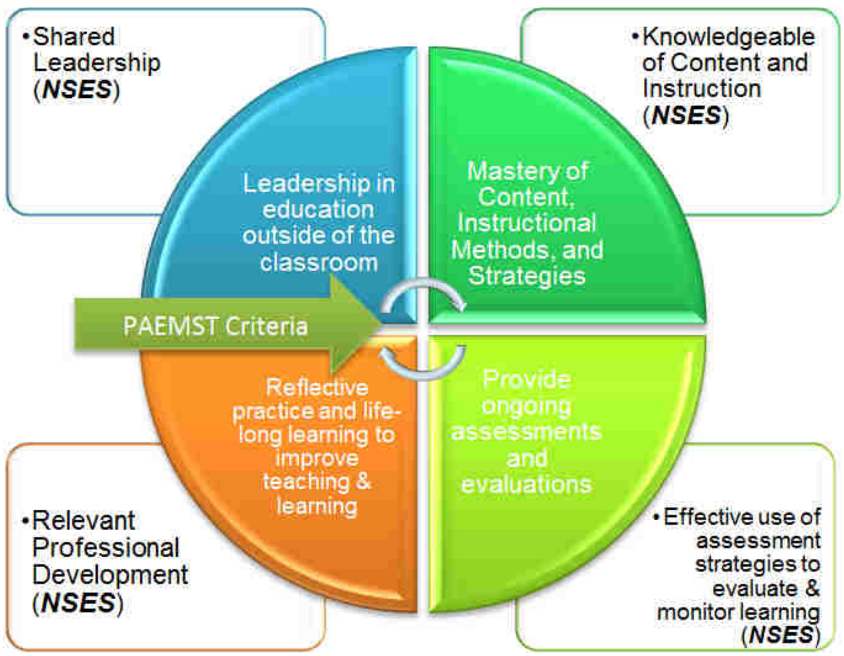

Figure 2. Interconnectedness of National Science Teachers Association's search for Excellence in Science Teaching (1980), as aligned to the *National Science Education Standards* & criteria for the Presidential Awards for Excellence in Mathematics and Science Teaching.

The Dimensions and the Standards suggest that science teachers need to be knowledgeable about science, provide a stimulating environment for students, and facilitate the understanding of concepts. They suggest that the development of expertise in science teaching requires an understanding of the learning environment, and the context of teaching is crucial to the success of teaching science. This along with the search for excellence in science teaching provided the framework for the criteria to be an exemplary science teacher (refer to

Figure 2) as aligned to the PAESMT's dimensions and the *National Science Education Standards.*

Description of Exemplary Science Programs

The exemplary science programs described in this study operated in two high schools. Observations were made at each site, science leaders were interviewed at each site, and science documents were collected at each site. The sites were identified by fictitious names and the science leaders were identified by fictitious names from each site.

School A: Douglas Charter High School

Fifteen years ago, in the summer of 1998, parents envisioned a public charter high school that would provide a rigorous college preparation taught in a "hands-on" manner, with a strong focus on critical thinking, sharing ideas, creating, and the constructivist classroom, or what they call active, social, creative learning. Still more important is their focus on citizenship in its broadest and deepest meanings. Note the words of their mission statement:

> The mission of Douglas Charter High School challenges college-bound students in a creative and supportive atmosphere to become knowledgeable, thoughtful, contributing citizens.

Douglas Charter High School (DCHS) is located near Academy Square in an architecturally stunning set of buildings near colleges and universities. The buildings have an impressive entrance, shiny pine floors and ceilings, and nine foot, double hung sash windows. The interior of the school retains the exposed brick walls and sealed pine floors and ceilings. The fully renovated administration building, built in 1910 houses the administrative offices and classrooms for subjects including biology, math, English, social studies, languages, art, music and drama. New space in the adjacent Carter building, built in 1894 have ten classrooms including a chemistry lab, computer lab, and new physics lab. New space for music classes was added in 2004.

Douglas Charter High School is characterized by its small class size, involved parents, highly qualified teaching staff, and students who are full partners of the staff in their education. The school currently enrolls 542 students in grades 9 through 12 and enjoys a student-to-faculty ratio of 19:1 ratio. In the absence of buses, parents drive and carpool students to and from school. DCHS is committed to creating a school environment which is culturally rich and reflective of the community in which students, faculty, and staff live. While the student population consists of 6% African American, 5% American Indian, 15% Asian, 64% Caucasian, 5% Hispanic, 5% Two or More Races, 5% Economically Disadvantaged, 5% Students with Disabilities, and 5% Limited English Proficiency students, Douglas Charter High School seeks to increase the diversity of their student body and faculty.

In 2001, DCHS became the first high school in the state to be named a School of Excellence. The school has been ranked as high as 34th in Newsweek’s Challenge Index (2012) and as high as 11th in U.S. News and World Report’s America’s Best High Schools for Math and Science (2011).

Douglas Charter High School is a college preparatory school that combines a demanding honors-level curriculum with the enrichment of numerous field experiences. At DCHS, a number of “special days” represents an essential element of the school’s citizenship mission: community involvement and outreach. Flexible (Flex) schedule days offer field experiences and extended learning. Students leave the familiar structure of the 45-minute classroom period, in many cases venturing off the DCHS campus.

Flex Days occur once each semester over two successive Fridays. Regular classes are cancelled and students instead meet in half-day sessions to pursue projects in different subject areas. These sessions allow teachers to introduce or to explore important topics in greater depth, often with an eye towards strengthening the school’s relationship with the surrounding community. Science Flex Days includes field trips to a Field Naturalist Museum, a North State Water Reclamation Facility, and to the Piedmont Biofuels. DCHS extended day program offer opportunities for students to participate in clubs such as; Ocean Science, Science Bowl, Green Club, Envirothon, and Science Olympiad. Douglas Charter High School competed in the National Science Olympiad in 2004 - 2012. They won the state Science Olympiad title in 2004.

Twelve years ago, two biology teachers who are participants in this study began coaching a Science Olympiad team at Douglas Charter High School. Seven years later a Community Work Day group grew out of this club: The Elementary Science Olympiad team was born. Each year, Karrington and Harris coach 30 DCHS students in planning and organizing the event for students from 15 private, home and charter elementary schools. It is a true “Olympiad.” Students from each school compete individually and in small group events. There are 18 events, including 6 building events with a focus ranging from thermodynamics to pasta-based engineering.

Douglas Charter High School offers 30 honor courses and 21 Advanced Placement courses. In 2012, 317 students in grades 9–12 took 735 Advanced Placement exams in 25 areas; 94% received scores of 3 or better. Advanced Placement Environmental Science examination takers were ranked number one in the world for a school of the size of Douglas Charter High School in 2005 and 2006. A summary of the honors and advanced placement courses offered in the science department at Douglas Charter High School is shown in Table 8.

Table 8

Honor and Advanced Placement Science Courses at DCHS

Honor Courses	**Advanced Placement Courses**
Honors Astronomy	Advanced Placement Biology
Honors Biology	Advanced Placement Chemistry
Honors Chemistry	Advanced Placement Environmental Science
Honors Environmental Science	Advanced Placement Physics B
Honors Physics	Advanced Placement Physics C

The first factor Principal Dr. Carter mentioned when asked what he attributed to the success of DCHS’s science department was the staff. He defined a great teacher, as “A mind at work. Our teachers are kind, caring, and smart.” The science teachers at DCHS are described as highly qualified teachers.

Science teacher: Mrs. Barbour. Prior to teaching, Mrs. Barbour worked in a Bio-Medical laboratory for 15 years. She has been teaching science for a total of 8 years. Mrs. Barbour taught science 2 years in a private high school prior to teaching science 2 more years in a public high school setting. She has taught Biology and Advanced Biology for the last 4 years at Douglas Charter High School. Since teaching science at Douglas Charter High School, Mrs. Barbour has shared classrooms with other teachers within the science department. She is in responsible for organizing one of the science Flex-Days at Douglas Charter High School. Mrs. Barbour has received Science Olympiad training, North Carolina Teach training and numerous professional development opportunities to enhance teaching strategies in her classrooms. She is currently assisting other teachers with the Science Olympiad and the Biology clubs at Douglas Charter High School.

Science teacher: Mrs. Cramer. Mrs. Cramer has been teaching science for the last 7 years at Douglas Charter High School. She has only taught at this school and she has only taught Advanced Placement Environmental Science. Before teaching, she worked as an Environmental Chemist for two different consulting firms. The first job was located in Kansas City and the other one was in the Academy Square area. The first job involved research for the EPA to develop improved testing methods for smoke stack emissions. The second job focused on developing federal regulations for several air pollution source categories. She belonged to the Air and Waste Management Association during several of those years.

Mrs. Cramer has received professional development in additional Environmental Science best practices and other teaching practices. She belongs to the Advance Placement list-serv for teachers that teach advanced placement classes. Mrs. Cramer attends the Advance Placement workshop each year during the summer and she is currently in charge of the Environ-thon club at Douglas Charter High School.

Science teacher: Mr. Harris. Mr. Harris has taught science for 25 years. He taught science for 12 years in a traditional public high school setting and in Japan. Mr. Harris has taught science for the last 13 years at Douglas Charter High School. He currently teaches Oceanography, Advanced Placement Biology and Science Research. In the past, Mr. Harris has taught Biology II, Academic Biology, Academic Chemistry, Honors Chemistry, Enriched Honors Chemistry, Physical Science, Earth Science, and Marine Biology at Douglas Charter High School.

Mr. Harris belongs to the National Science Teacher Association, the Advance Placement listserv for Advance Placement Biology, and a member of the Marine Educators Association. Mr. Harris attends the advance placement workshop each summer as well as other professional development opportunities including the Science Olympiad workshops. Mr. Harris is currently the Science Olympiad coordinator and advisor of the Science Olympiad and Oceanography clubs at Douglas Charter High School.

Science teacher: Mrs. Karrington. Mrs. Karrington has been teaching at Douglas Charter High School since it opened. She has been teaching Advanced Placement Psychology, Biology, Advance Placement Biology, and Honors Chemistry for the last 17 years. She is currently the science department chair. In this role, Mrs. Karrington attends school improvement meetings to represent and advocate for the science department.

Mrs. Karrington worked as research assistant in a molecular genetics laboratory for 2 years prior to working at Douglas Charter High School. She is attends the advance placement workshops during the summer and is a member of the Advance Placement listserv for Psychology and Biology. Mrs. Karrington assist with the Science Olympiad, Science Bowl and Psychology clubs at Douglas Charter High School.

Science teacher: Mrs. Whitman. Mrs. Whitman has been teaching science for the last 47 years. She taught Physics in several traditional public high schools and has spent the last 7 years teaching Advanced Placement Physics and Non-Calculus Advance Placement Physics at Douglas Charter High School. Mrs. Whitman received the Presidential Award for Excellence in Mathematics and Science Teaching in 1998. She was a Kenan Fellow from year 2010 to 2012. She evaluated Virtual Public High School online Physics programs has wrote essential standards in Physics for the state department. Mrs. Whitman belongs to the American Association of Physics Teachers and the North Carolina Science Teachers Association she has written grants that have totaled $15,000 for Douglas Charter High School this school year; 2012-2013.

Mrs. Whitman currently oversees a science Flex-Day at Douglas Charter High School. She is the advisor for the physics club and participates in the online listserv for Advance Placement Physics.

Principal: Dr. Carter. Dr. Carter has been the principal at Douglas Charter High since it opened in 1999 and he is also the Curriculum Coordinator for the school. Dr. Carter has also taught English several times at the school. Prior to his principal-ship at Douglas Charter High School, he was an Advance Placement English teacher in a traditional public high school for 19 years. Dr. Carter is currently a member of the College Board Advance Placement Consultant for Advance Placement English Language and Composition.

A description of the 5 science teachers and the principal that participated in this study is shown in Table 9.

Table 9

Demographics Information for Participants

Participants	Position	Years of Experience (as of 2013)	Courses Taught	Gender	Race
Barbour	Science Teacher	8	Advance Placement Biology, Biology	Female	White

Table 9

(Cont.)

Participants	Position	Years of Experience (as of 2013)	Courses Taught	Gender	Race
Carter	Principal, Curriculum/ Instructional Leader	14 years as Principal at DCHS	English	Male	White
Cramer	Science Teacher	7	Advance Placement Earth/Environmental Science, Bio-Chemistry	Female	White
Harris	Science Teacher	25	Advance Placement Biology, Biology, Ocean Science	Male	White
Karrington	Science Teacher, Science Department Chair	17	Advance Placement Biology, Advance Placement Psychology, Biology, Chemistry	Female	White
Whitman	Science Teacher	47 (PAEMST-1998) Presidential Awards for Excellence in Mathematics and Science Teaching Recipient	Physics	Female	White

Science classrooms. The science classrooms at Douglas Charter High School are located in different locations in the school, which is why detailed explanations of each of the teachers' classrooms are described individually. Regardless of class separations, these teachers are able to maintain an exemplary science program. Some classrooms at DCHS are located downstairs while others are located upstairs. Several teachers float to different classrooms and almost all teachers share their classrooms. The classrooms at DCHS are relatively small, however the classes house between 20 to 30 students. The classrooms come equipped with the basic white board, some storage space, teacher work area, tables and chairs for the students, and most rooms have a LCD projector. The classrooms are set up with a focus on teaching and learning. However the teachers facilitate instruction while the students work together in groups to achieve goals and objectives which are classroom environments that are necessary to help students learn and understand challenging and important science skills (NRC, 1996).

Karrington's classroom. The classroom is very small and cozy and is located downstairs near the main office. The eight student tables are arranged in two rows connected across the classroom. There are a total of 36 students' chairs in the room. All tables and chairs are facing the front of the room which appears to be determined based on the position of the overhead projector. Inspirational posters hang on the beige walls. The floor is aligned with gray carpet, which was surprising for me to see in a science classroom. Science books located on two bookshelves are indicators that I am in a science classroom. There is one huge window located in the room. The blinds on the window are closed which make the space in the room feel small and cozy. Mrs. Karrington's desk faces the window. Four stackable trays labeled Advanced

Placement Biology, Advanced Placement Psychology, and Biology are located on her desk as well as an Apple laptop computer.

Harris's classroom. Mr. Harris's classroom is located downstairs in the middle of the hallway. The layout of Mr. Harris's classroom is identical to Mrs. Karrington's classroom. The window in Mr. Harris's classroom is not covered in blinds or curtains so therefore the room is bright. Mr. Harris's desk is located near the window but facing the front of the room. The students' tables and chairs are connected and positioned in a "U" shape and face the front of the room. The position of the overhead projector determines the focal point for the front of the room. The adjacent wall displays painted beach scenery. The grassy area, the sandy shore, and the beach chairs in addition to the ocean view in the background seem to present a fun and relaxing atmosphere. The other walls are beige and the carpet in Mr. Harris's room is gray. From a distance, I could see a laptop computer on Mr. Harris' desk as well as stacks of paper. Science books, science workbooks, two empty aquarium tanks, science posters and charts are located on the bookshelves and walls. Familiar laboratory equipment such as; beakers, test tubes, science kits, cell models, and Deoxyribonucleic Acid (DNA) models are also located on the bookshelves located throughout the room.

Cramer's classroom. Cramer's classroom is located downstairs at the end of the hallway. The size of the room is consistent with the size of Karrington and Harris' rooms and the floors are covered with gray carpet. The large window that takes over most of the wall in the back of the room allows light to shine through which makes the room bright. There are a total of nine tables in the room. There are a total of three seats at each of the nine tables. The tables and chairs are arranged in two rows facing the white board. The LCD projector faces the white board. Posters of maps; *Exploring the Earth Using Seismology, The Outer Banks, Layers of Life*, are displayed on the walls throughout the classroom. A picture of Einstein is also displayed on the wall. Science posters such as; *Stellar Evolution Rocks, Eons of Life, and Greenhouse Earth* are displayed on the walls. Science text books and student resources such as; pencil sharpener, hole puncher, stapler and staples are located on the book shelf. The teacher's desk is located in the corner near the back of the room. A computer, pictures of a bird and family or friends, scissors, tape, and worksheets are located on Mrs. Cramer's desk. A row of cabinets with a black counter top is located along the wall in the back of the room. A sink is located in the middle of the counter top.

Whitman's classroom. Mrs. Whitman shares a classroom with another science teacher. The classroom is located upstairs near the middle of the hallway. Gray tiles cover the floor and the size of the room is consistent with the other science rooms. Overhead cabinets with open storage and countertops with cabinets underneath align the room. Four baskets are on the countertops labeled "Graded Work." The baskets are green or blue with the number; 1, 2, 3, or 4 on them. Other baskets are found in the cabinets. These baskets are filled with the following items:

- Student notebooks
- Motion Detectors
- Stop watches
- Clamps
- Super Rockets
- Styrofoam balls
- Graduated cylinders,
- Beakers
- Wooden blocks
- Electric Balances
- Protractors, and
- Other laboratory items.

Three student tables are located in rows near the front of the room and four student tables are located in rows behind the first row of tables. Three chairs are place at each of the tables and the tables face the white board in the room. Long orange internet wires hang from the ceiling above the tables. Mrs. Whitman's class does not have a LCD projector. The large window allows sunlight to brighten the room. Mrs. Whitman's desk is located in the back of the room near the sink and the window. Mrs. Whitman's certificates, honors and awards are displayed on the bookshelf found behind her desk.

Barbour's classroom. Mrs. Barbour also shares a classroom with another science teacher. The classroom is located upstairs at the end of the hallway. Mrs. Barbour's classroom is larger than the other participants' classrooms. Once again, students' tables and chairs and the LCD projector are positioned towards the white board. Four student tables are found in rows on each side of the room with two student chairs placed at each table. The blinds on the large window are closed so therefore the room is dark. The floors are aligned with gray tiles. Due to the size of the room, an abundance of cabinets align the beige walls with black countertops around the room. The cabinets are labeled with the name of different items that are found in science classrooms such as:

- Funnels
- Beakers
- Stands
- Tongs
- Test tubes
- pH paper
- Pipet bulbs
- Pipettes
- Lab notebooks
- Chemicals

Mrs. Barbour’s desk is located in the middle of the room near the window. Baskets labeled 1st period, 2nd period, 3rd period, and 4th period are on her desk. Student work, biology textbooks, and biology supplemental workbooks are located on the bookshelf behind Mrs. Barbour’s desk.

Biology performance data. Evidence from the state performance data supports the perspective that Douglas Charter High School have been successful in improving academic outcomes for all students in standards-based science programs. First, the data for students in 2011-2012 reveal that 95% of the students in Biology at Douglas Charter High School scored at or above grade level. Until 2012, North Carolina students in grades 3-8 completed annual ABCs End-of-Grade tests in reading, mathematics and science (grades 5 and 8). Students enrolled in the following courses completed End-of-Course tests: English I, Algebra I, and Biology. Results from tests taken by students in Douglas

Charter High School are reported in Table 10. (In the 2011-12 school year, the End-of-Course tests in Physical Science, Algebra II, Civics and Economics, and U.S. History were eliminated from the testing program.)

Table 10

Douglas Charter High School Performance of Students in Each Course on the ABCs End-of-Course Tests

	English I	Algebra I	Algebra II	Biology	Physical Science	Civics & Economics	US History
Our School	>95%	>95%	---	>95%	---	---	---
# of Tests Taken	137	36	---	137	---	---	---
State	82.9%	78.7%	---	83.0%	---	---	---

Source: North Carolina Department of Public Instruction/North Carolina ABC's Accountability

Coupled with this proficiency of students in Biology at Douglas Charter High School were student outcome data on the state accountability measure (North Carolina End-of-Course; EOC) that demonstrates that DCHS has become a highly effective school. Based on their performance on the state's ABCs tests, Douglas Charter High School's Designation during the 2011-2012 school year were; Honor School of Excellence and High Growth during the 2011-2012. These designations were awarded based on the percentage of students performing at grade level and on whether students have learned as much as they are expected to learn in one year. The designations earned by Douglas Charter High School are displayed in Table 11.

Table 11

Douglas Charter High School's Performance (2011-2012)

		Growth Learning achieved in one year			
Designation	**Performance: Students Performing at grade level**	**High Growth**	**Expected Growth**	**Expected Growth Not Achieved**	**Percent of State Schools with Designation**
Honor School of Excellence	At least 90% of students at grade level and the school made expected growth or more & met all AMO targets	✓		--	20%
School of Excellence	At least 90% of students at grade level			--	2%
School of Distinction	80 to 90% of students at grade level			--	30%
School of Progress	60 to 80% of students at grade level			--	27%
No Recognition	60 to 100% of students at grade level	--	--		19%
Priority School	50 to 60% of students at grade level or less than 50% of students at grade level				2%

Source: North Carolina Department of Public Instruction/North Carolina ABC's Accountability

Data indicated that students substantially exceeded state averages in not only Biology, but in English I and Algebra I at Douglas Charter High School. This data supports the perspective that Douglas Charter High School has developed model science programs for improving outcomes for all students.

School B: Jefferson High School

Three miles southwest of a major interstate, far enough from the lakes for roads to stay straight for reasonable distances, sits Jefferson High School (Jefferson). Opened in 1963, it is one of Grayson Public School's (GPS) traditional, 9–12 high schools. With a shopping mall across the street and vast stretches of neighborhoods and apartment complexes in every other direction, it is the most suburban in appearance of the district's six high schools. The parking lot is packed with teacher and student cars, students walking to school, and the few cars dropping students off. A ringing bell is all it takes for one to remember what walking through a building filled with 1,818 students looks and feels like.

Entering Jefferson, visitors immediately get the sense that this is a busy school. Video monitors run ongoing announcements as well as the different activities taking place throughout the school year. A display showcases athletic trophies and awards from the variety of sports that the school offers. An African American female student in the office reads the current announcements on the intercom with so much excitement while the office is a beehive of students, teachers, and people solving little problems.

The students in the halls appear racially and ethnically diverse and very nearly mirror the demographics of the district with 40% African American, 6% Asian,39% Caucasian,11% Hispanic/Latino, and 4% Other and Multi-Racial Groups. Approximately 30% of the student body qualifies for free or reduced lunch. Jefferson's population of students characterized as Economically

Disadvantaged (39%) is slightly less than the district average (41%). Jefferson also has similar student ratios in terms of individuals classified as Students with Disabilities (8%) and as Limited English Proficiency Learners (8%) as the district.

Two years ago, JHS converted to an A/B day schedule for all grade levels. Until then, juniors and seniors took classes on a hybrid block schedule. In the past decade, JHS has offered twenty-three honor courses and nineteen Advanced Placement (AP) courses. Historically, 500 (29.4%) of the students are enrolled in one or more AP courses each year and 665 (76%) of the students passed their particular Advanced Placement Exam with a score of 3 or higher. In addition to the AP scores, the SAT score averages are higher than the State average (1475), the District average (1403) and the National average (1500), while Jefferson High School's average is at 1503. A summary of the honors and Advanced Placement courses offered in the science department at Jefferson High School is shown in Table 12.

Table 12

Honor and Advanced Placement Science Courses at JHS

Honor Courses	**Advanced Placement Courses**
Honors Biology	Advanced Placement Biology
Honors Chemistry	Advanced Placement Chemistry
Honors Physics	Advanced Placement Environmental Science
Honors Science	Advanced Placement Physics C
Honors Anatomy and Physiology	

Jefferson High School is a diverse school rich in traditions of academic and extra-curricular excellence. Another important aspect of the academic program is the availability of a wide variety of clubs. Students are encouraged to participate in opportunities such as National Robotics State Champions, NASA competition, Science Quiz Bowl, Science Olympiad team, Physical Science club, math competitions, band competitions, choral competitions, art contests, writing contests, academic clubs, and independent studies for enrichment.

Howard's, Talbert's, Walter's, and Harold's classrooms. Soon enough, I arrive at the second floor of the eastern end of the school where all of the science classrooms are located which provide opportunities for the teachers to be a science department and therefore maintain an exemplary science program. These classrooms are large size rooms with a total of 30 individual student desks in every room. The back walls are aligned with windows that provide an array of sunshine into the rooms. The black counter tops that are found in most high school science classrooms run along the walls of the classrooms with sinks and cabinets located beneath. All classrooms have LCD projectors and one computer. Textbooks and other supplemental resources located on the counter tops and bookshelves help one to identify what type of science courses are taught in each of the rooms. The walls in the rooms are filled with motivational posters such as; *The Harder you Work The Luckier you Get, Don't Quit, Knowledge is Power and Learning is a Lifetime Achievement*. The walls are also filled with scientific posters such as; *Science Inspirations, Even Einstein Asked*

Questions, and Biology It Grows On You. The white boards which identifies the front of the room displays the daily agenda, science essential questions, science objectives and or “I” CAN statements. Sharing standards with students is also a means of providing them with clear guidelines for demonstrating and evaluating their learning (NRC, 1996). The teachers’ desk, pictures of teachers’ family and friends, classroom pets housed in aquariums, empty aquariums, laboratory equipment, tools and supplies can be found in many different areas within all classrooms.

The classrooms are set up with a learner in mind; it is full of teacher made activities and bulletin boards where the learner could demonstrate their knowledge about science by answering the questions posted on the boards. The boards are also displayed with scientific facts. The desk arrangement is U-shaped, where the students can openly discuss any topic viewing their classmates and the teacher. The classroom comes equipped with the basic essentials and the teacher has at least one projector computer in the room. The storage rooms are filled with science textbooks, boxes of laboratory kits, and mountains of fascinating science equipment that gives the sense that if one had the run of the place, there would be a lifetime of interesting objects to examine.

Except for the teachers who are planning, most teachers are teaching classes. Majority of the teachers at Jefferson High School (97%) are highly qualified teachers. 37% of the teachers have advanced degrees and 18 of the teachers are National Board Certified which exceeds the district and state averages. In addition to the science teachers at Douglas Charter High School being highly qualified teachers, the science teachers at Jefferson High School are also highly qualified teachers.

Science teacher: Mr. Harold. Mr. Harold has been teaching science for 28 years. He taught middle school science for 16 years and has taught at Jefferson High School for the past 12 years. He has taught physical science, honors biology, biology and earth science. He currently teaches Biology and Earth/Environmental Science classes. Mr. Harold has been a member of the MSEN (Mathematics and Science Education Network) program for the last 15 years and belongs to the North Carolina Science Teachers Association. He has attended numerous professional development workshops to enhance his science teaching practices at Jefferson High School.

Science teacher: Mrs. Hilliard. Ms. Hilliard has been teaching science for the last 9 years. She taught middle school science, math and French for 2 years prior to teaching at Jefferson High School. Ms. Hilliard has taught Earth Science, Physical Science, Biology, Anatomy/Physiology and Advance Placement Biology at Jefferson High School. She currently teaches biology and earth science and is the science chair for the department. Ms. Hilliard organizes after school tutoring for the students and teachers in the science department and advocates and represents the science department on the school improvement team.

Ms. Hillard belongs to the North Carolina Science Teacher Association and attends numerous research professional development opportunities during the summer and throughout the school year such as; working with entomologist at North Carolina State University, Kenan Fellow since 2010, and working at the Duke Clinical Research Institute. She was nominated for the Presidential Awards for Excellence in Mathematics and Science Teaching Nominee in 2009 and Ms. Hilliard is the advisor for the Biology club she provides professional development for science teachers within the district and for Jefferson High School.

Science teacher: Mrs. Talbert. Mrs. Talbert has been teaching science for the past 13 years. She is currently teaching Biology, Advance Placement Biology, and Honors Anatomy and Physiology. Prior to teaching, Mrs. Talbert worked in 2 research laboratories. In the Chesapeake Biological Research Lab, she looked at birds exposed to the chemical PCP. She looked at mutations and yeast and how they affect the frame shifts and genetic mutations of sheep in the research laboratory at the University of Maryland. She was a Distinguished Albert Einstein Fellows which provided opportunities for her to work in Washington, D.C. in a congressman office looking at education policies and STEM education. Mrs. Talbert was also provided opportunities to work in Trinidad in order to study leatherback sea turtles.

Mrs. Talbert belongs to the National Association for Biology Teachers, North Carolina Science Teachers Association and the STEM Educated Resource Team. She participated in the Advance Placement workshop for biology and belongs to the online listserv for Biology, and wrote the Advance Placement Biology curriculum and Biology curriculum for the state of Maryland. Mrs. Talbert provides professional development for science teachers within the district and for Jefferson High School.

Science teacher: Ms. Walter. Ms. Walter has taught science for the last 2 years at Jefferson High School. She completed her student teaching at Jefferson High School. She currently teaches Honors Biology, Marine Science, and Earth/Environmental Science at Jefferson High School. Ms. Walter belongs to the North Carolina Science Teachers Association. She attends numerous professional development opportunities provided in the district and she is the advisor for the Science Olympiad and Marine Science clubs at Jefferson High School.

District Science Coordinator: Mr. Davis. Mr. Davis has been the district science coordinator for the past three years. Mr. Davis taught Advance Placement Earth/Environmental Science, Physics, Biology, Physical Science, Marine Science in addition to some online science courses for 15 years at Jefferson High School. He belongs to the National Science Teacher Association and the North Carolina Science Teacher Association and is a Kenan Fellows.

Mr. Davis provides numerous professional development opportunities for all science teachers in the district. He assists science departments with supplemental resources to enhance teaching and learning and he also observe science classes to promote exemplary science practices.

Assistant Principal: Mr. Henderson. Mr. Henderson has been an assistant principal at Jefferson High School for the past 2 years. He was a high school History teacher for 10 years prior to working as an assistant principal. Mr. Henderson attends numerous professional development opportunities within the district in all content areas, including science. He observes science classes and provides feedback and suggestions that are aligned to science standards and best practices.

A summary of the highly qualified demographic information of participants is shown in Table 13. The assistant principal describes the science department as one of the best departments at Jefferson High School. He stated that "the science teachers are leaders in their content. There is no denying it, this would be an engaging group of people to have as colleagues."

Table 13

Demographic Information for Participants

Participants	Position	Years of Experience (as of 2013)	Courses Taught	Gender	Race
Davis	District Science Coach	3 years as coach, 15 total years as an educator	Earth/ Environmental Science	Male	White
Harold	Science Teacher	28	Biology, Earth/ Environmental Science	Male	White
Henderson	Assistant Principal, Instructional Leader for Science Department	2 years as Assistant Principal, 10 years total as an educator	History	Male	Black

Table 13

(Cont.)

Participants	Position	Years of Experience (as of 2013)	Courses Taught	Gender	Race
Hilliard	Science Teacher, Science Department Chair	13 (PAEMST2009) Presidential Awards for Excellence in Mathematics and Science Teaching Recipient	Biology, Honors Biology	Female	White
Talbert	Science Teacher	13	Advance Placement Biology, Biology, Honors Anatomy & Physiology	Female	Black
Walter	Science Teacher	2	Honors Biology, Marine Science, Earth/Environ mental Science	Female	White

Biology performance data. Evidence from the state performance data supports the perspective that Jefferson High School has been successful in improving academic outcomes for all students in standards-based science programs. First, the data for students in 2011-2012 reveal that 89.7% of students in Biology at Jefferson High School scored at or above grade level. Until 2012, North Carolina students in grades 3-8 completed annual ABCs End-of-Grade tests in reading, mathematics and science (grades 5 and 8). Students enrolled in the following courses completed End-of-Course tests: English I, Algebra I, and Biology. Results from tests taken by students in Jefferson High School are reported in Table 14. (In the 2011-12 school year, the End-of-Course tests in Physical Science, Algebra II, Civics and Economics, and U.S. History were eliminated from the testing program.)

Table 14

Jefferson High School Performance of Students in Each Course on the ABCs End-of-Course Tests

	English I	Algebra I	Algebra II	Biology	Physical Science	Civics & Economics	US History
Our School	80.3%	43.0%	---	89.7%	---	---	---
# of Tests Taken	411	300	---	379	---	---	---
District	75.7%	67.1%	---	75.4%	---	---	---
State	82.9%	78.7%	---	83.0%	---	---	---

Source: North Carolina Department of Public Instruction/North Carolina ABC’s Accountability

Coupled with this proficiency of students in Biology at Jefferson High School were student outcome data on the state accountability measure (North Carolina End-of-Course; EOC) that demonstrates that JHS has become a highly effective school. Based on their performance on the state's ABCs tests, Jefferson High School's Designation during the 2011-2012 school year were; School of Distinction and High Growth. These designations were awarded based on the percentage of students performing at grade level and on whether students have learned as much as they are expected to learn in one year. The designations earned by Jefferson High School are displayed in Table 15.

Table 15

Jefferson High School's Performance (2011-2012)

		Growth Learning achieved in one year			Percent of Schools with Designation	
Designation	**Performance: Students Performing at grade level**	**High Growth**	**Expected Growth**	**Expected Growth Not Achieved**	**District**	**State**
Honor School of Excellence	At least 90% of students at grade level and the school met all AMO targets			--	20%	20%
School of Excellence	At least 90% of students at grade level			--	0%	2%
School of Distinction	80 to 90% of students at grade level	✓		--	0%	30%
School of Progress	60 to 80% of students at grade level			--	40%	27%
No Recognition Priority School	60 to 100% of students at grade level 50 to 60% of students at grade level or Less than 50% of students at grade level	--	--		30% 10%	19% 2%

Source: North Carolina Department of Public Instruction/North Carolina ABC's Accountability

As the data shows, students exceeded district averages in English I and Biology at Jefferson High School. This data supports the perspective that Jefferson High School has developed model science programs for improving outcomes for all students.

Data Collection

According to Creswell (2007) data collected in a case study is extensive because it draws upon multiple sources. Creswell (2007) cited observations, interviews, documents, and audiovisual materials as commonly used sources in case studies. I used interviews, observations, and documents (teacher evaluations, student data sheets, emails, North Carolina School report cards, and lesson plans). Lunenburg and Irby (2008) further explained that “data collection describes precisely the physical things the researcher does to obtain data from participants. It indicated what steps were taken before, during, and after data collection” (p. 194). Patton (2002) explained that,

> qualitative data consist of direct quotations from people about their experiences, opinions, feelings, and knowledge obtained through interviews; detailed descriptions of people’s activities, behaviors, actions recorded in observations; and excerpts, quotations, or entire passages extracted from various types of documents. (p. 4)

Interviews were open-ended in order to permit and encourage science leaders to use their own words in describing how their leadership practices were connected to science standards in order to improve student learning. Merriam (2009) stated that “interviewing is the best technique to use when conducting intensive case studies of a few selected individuals” (p. 88). Furthermore, “interviewing can be used to collect data from a large number of people representing a broad range of ideas” (p. 88). Dexter (1970) stated that, “interviewing is the preferred tactic of data collection when . . . it will get better data or more data or data at less cost than other tactics" (p. 11). I conducted two interviews with each participant. The second interview allowed me to do member checking. The first interviews lasted approximately 60 minutes. The second interviews lasted approximately 30 minutes. Interview questions were developed in alignment with the criteria outlined in the *National Science Education Standards*. Interviews took place either in teachers' classrooms during planning time or in administrators' offices.

Interviews are a primary source of data in qualitative research; so too are observations. Observations take place in the setting where the phenomenon of interest naturally occurs and observational data represent a firsthand encounter with the phenomenon of interest (Merriam, 2009). I observed science educational leaders' practices in science classrooms. "One reason to conduct observations was to provide some knowledge of the context or to provide specific incidents, behaviors, and so on that can be used as reference points for subsequent interviews" (p. 119). For example, when I observed science leaders connecting practices to standards, I asked participants specific questions about their practices that were witnessed during the observation. Observations made it possible to record behavior as it happened. "Observations were also conducted to triangulate emerging findings; that is, they were used in conjunction with interviewing and document analysis to substantiate the findings" (p. 119). All participants were observed one time for 30 minutes within science classrooms. I shadowed administrators while they evaluated science teachers.

Interviewing and observing are two data collection strategies designed to gather data that specifically address the research questions. Documents are usually produced for reasons other than the research. This qualitative study of exemplary science programs led to documents in the form of teacher evaluations, student data sheets, emails, North Carolina School report cards, and lesson plans. I kept an open mind in discovering and using documents. “Being open to any possibility can lead to serendipitous discoveries” (Merriam, 2009, p. 150). Documents helped me to uncover meaning, develop understanding, and discover insights relevant to the research problem.

Interview Protocol

The purpose of the interview questions (see Appendix D and Appendix E) was to elicit science leaders’ practices within exemplary standards-based science programs. Understanding these practices may be useful feedback that will bridge the gap between research and best practices for contributions in science education. Interview questions were developed using criteria outlined in the *National Science Education Standards*. Patton (2002) stated that “the questions serve as an interview guide and help ensure that the same questions are asked of each participant” (p. 22). Probing questions were used in order for the science leaders to provide additional information as needed. Interviews were open-ended. This provided opportunities to prompt science leaders for further information.

Observation Protocol

The purpose of conducting observations (see Appendix F) was to observe how science educational leaders translated the science standards into practice. Observations made it possible to record behavior as it happened. An observational case study is one in which “the major data-gathering technique was participant observation (supplemented with formal and informal interviews and review of documents) and the focus of the study is on a particular organization (school) or some aspect of the organization” (Bogdan & Biklen, 2007, p. 60); science educational leaders and science standards. Merriam (2009) stated that “Observations are also conducted to triangulate emerging findings; that is, they are used in conjunction with interviewing and document analysis to substantiate the findings” (p. 119).

Documents Protocol

The purpose of gathering data from documents (see Appendix G) was to analyze and learn directly how they translated science standards into practice. “Documents reveal goals or decisions that might otherwise be unknown to the evaluator” (Patton, 2002, p. 293). The data found in documents were used in the same manner as data from interviews or observations (Merriam, 2009). Merriam (2009) further explained that “the data can furnish descriptive information, offer historical understanding, track change and development, and so on” (p. 155).

Documents such as teacher evaluations, student data sheets, emails, North Carolina School report cards, and lesson plans helped provide information on curriculum, instruction, assessment, evaluation, professional development, and leadership practices. Using multiple data collection strategies assisted in presenting how science leaders and science standards within exemplary science programs enact change in the science community.

Data Analysis Procedures

Data collection and data analysis were an on-going process in this qualitative research. The qualitative data analysis consisted of examining and categorizing the evidence. The methodology used was a multi-site case study because of the potential, through cross analysis, for providing greater explanation of the findings in the study (Merriam, 1988).

Qualitative researchers use coding and data displays to help organize, classify, and find themes in their data. Data collection was gathered during interviews, observations, documents, and field notes. Member checks were used to triangulate the findings and to develop converging lines of inquiry through the data (Lincoln & Guba, 1985; Yin, 2003). Each interview was digitally recorded and transcribed. To find meaningful connections I stayed close to the data as it was originally recorded, which allowed themes to emerge from the data (Glesne, 2006). The data coding consisted of reading and rereading the data to look for phrases and themes that existed within and across data sources (interviews, observations, and documents).

In the first phase, the initial framework themes dealing with exemplary programs as outlined in the *National Science Education Standards* included curriculum, instruction, assessment, evaluation, professional development, and leadership were used. Each participant's transcribed interviews and field notes were printed on different colors of paper to facilitate coding of data. In the second phase, each participant's interviews and field notes were printed again and color coded with markers to look for repetitive phrases within and across each data source. In the third phase, each of these phrases was placed in a table. In the fourth phase, the sub-themes were coded, which helped identify areas for further investigation. Concept Maps/figures were constructed to aid in the organization and presentation of the data. Finally cross-site analysis was used in the fifth phase to assist with the comparison of the two sites and analysis of the research questions.

Ethical Issues

According to Yin (2013), one of the most important sources of case study evidence is the interview. Observations serve as yet another source of evidence in doing case study research, and documentary information is likely to be relevant to every case study topic. Research relationships are "asymmetrical, with the power disproportionately located on the side of the researcher" (Glesne, 2006, p. 138). This requires the researcher to consciously consider and protect the rights of participants to privacy. Ethical considerations included: informed consent, protecting participants' anonymity, and the use of fictitious names (Glesne, 2006; Marshall & Rossman, 2006).

Another characteristic of good qualitative study is the sensitivity to the risks of human subjects (Stake, 1995). Stake (1995) advocates that the researcher should indicate how and why the organization was selected. To protect the participants, the school or school system is not identified. Participants had the right to make informed decisions about participating in the study and withdraw from the study at any time (Creswell, 1998; Glesne, 2006; Patton, 2002). This research was feasible and ethical, and participants' time was voluntary and not harmful.

This study was approved by the University of North Carolina at Greensboro Institutional Review Board (see Appendix A). The rights of participants for this study were protected in the following ways. Participants received an email with an invitation to participate (see Appendix B). Participants received an introduction to the study and their role in the process verbally and in writing. Teachers were asked to sign a written consent form detailing their participation and ability to withdraw from the study at any time (see Appendix C). Participants received a copy of the interview protocol and copy of interview questions (see Appendix D and Appendix E), observation protocol (see Appendix F) as well as document protocol (see Appendix G). Participants were identified with a fictitious name for the interview recording, transcription, and presentation of results to ensure their anonymity.

Trustworthiness

Both internal and external validity were considered. In insuring internal validity, the following strategies were employed: (a) triangulation of data—data were collected through multiple sources to include interviews, observations, and document analysis; (b) member checking—the participants served as a check during the second interview; (c) long-term observations at the research site-similar phenomenon and setting occurred on-site over a three-month period of time; and (d) clarification of researcher bias at the outset of this study researcher bias was articulated in writing under the heading "Researcher Role." The primary strategy utilized in this project to ensure external validity was the provision of rich, thick, detailed description so that anyone interested in transferability would have a solid framework for comparison (Merriam, 1988).

Three techniques to ensure reliability were employed in this study: (a) the researcher provided a detailed account of the focus of the study, the researcher's role, basis for selection, and the context from which data were gathered (Goetz & LeCompte, 1984); (b) triangulation, or multiple methods of data collection and analysis were used; this strengthens reliability as well as internal validity (Merriam, 1988); (c) data collection and analysis strategies were reported in detail in order to provide a clear and accurate picture of the methods used in this study.

Summary

In summary this chapter restated the purpose of this research and presented the research questions. The exemplary science programs were chosen and determined by having science teachers in the programs who are recipients of the Presidential Awards for Excellence in Mathematics and Science Teaching. The data collection included interviews and observations with 12 science instructional leaders as well as collection of document analysis. Data was collected with digital audio and with written field notes during interviews and observations. Observations and document analysis were used in order to triangulate and clarify information. A reflective journal was kept to identify biases and to help ensure objectivity. Finally, interviews were transcribed verbatim and the transcripts were offered for science instructional leaders to check for accuracy and intention. The results are discussed in the following chapter.

CHAPTER IV

RESULTS

This qualitative case study examined aspects of best practices in exemplary standards-based science programs as outlined by the *National Science Education Standards*. Included in this chapter is an exploration of how instructional science leaders used each of the standards with their students. This study also highlighted which standard is most critical for exemplary standards-based science programs. Implications for achieving the desired effect on teaching and learning were also identified.

Research Questions

The over-arching research question for this study was: What impacts have science instructional leadership and science standards had on the success of exemplary standards-based science programs? To provide focus for this research, the following research questions were developed:

1. How is science leadership exhibited in a standards-based program?
2. How are instructional practices, curriculum, and professional development aligned to science standards and supported in order to establish and achieve high expectations for students in science?
3. How does aligning assessments to science standards and evaluating standards-based science programs impact student learning?

4. Which standards are perceived by science educational leaders as most critical for an exemplary science program?

The findings focus on emergent themes that were gathered from the science instructional leaders' interviews, observations, documents, reflective journal, emails, coding, and analysis of the data. The findings of this study are presented in three sections. The first section contains an overview of the two high schools and the science programs chosen for this study. The second section describes the interviews, observations, and document procedures and introduces the data from the participants with a focus on instructional leadership practices and the use of standards in their instructional practices. The last section displays cross-case analysis.

Exemplary Programs as Aligned to *National Science Education Standards*

The *National Science Education Standards* were produced by the NRC in 1995 and published in 1996. Unlike other documents, the Standards deal concurrently with six aspects of science education:

- Standards for science teaching (instruction).
- Standards for professional development for teachers of science.
- Standards for assessment in science education.
- Standards for science content (curriculum).
- Standards for science education programs (evaluations).
- Standards for science leadership, (NRC, 1996, p. 3).

As suggested in the standards, teachers of science actively participate in the ongoing planning and development of the school science program. In doing this, teachers work with colleagues and others to improve and maintain a quality science program for all students. Although individual teachers continually make adaptations in their classrooms, the school itself must have a coherent program of science study for students (NRC, 1996). In the vision described by the *National Science Education Standards*, the teachers in the school and school district have a major role in designing that program, working together across science disciplines and grade levels, as well as within levels, (NRC, 1996). “When teachers and students have the opportunity to describe their own views about learning and teaching and to compare, contrast, and revise their views, they come to understand the nature of exemplary science teaching” (NRC, 1996, p. 67) and exemplary science programs.

Findings

Qualitative researchers use coding and data displays to help organize, classify, and find themes in their data. Data collection was gathered during interviews, observations, documents, and field notes. Member checks were used to triangulate the findings and to develop converging lines of inquiry through the data (Lincoln & Guba, 1985; Yin, 2003). Each interview was digitally recorded and transcribed. To find meaningful connections I stayed close to the data as it was originally recorded, which allowed themes to emerge from the data (Glesne, 2006). To find meaningful connections I stayed close to the data as it was originally recorded, which allowed themes to emerge from the data (Glesne, 2006). The data coding consisted of reading and rereading the data to look for phrases and themes that existed within and across data sources (interviews, observations, and documents).

In the first phase, the initial categories for investigating exemplary programs as outlined in the *National Science Education Standards* included curriculum, instruction, assessment, evaluation, professional development, and leadership were used. Each participant's transcribed interviews and field notes were printed on different colors of paper to facilitate coding of data. In the second phase, each participant's interviews and field notes were printed again and color coded with markers to look for repetitive phrases within and across each data source. In the third phase, each of these phrases was placed in a table. In the fourth phase, the sub-themes were coded, which helped identify areas for further investigation. Concept Maps/figures were constructed to aid in the organization and presentation of the data. Finally cross-site analysis was used in the fifth phase to assist with the comparison of the two sites and analysis of the research questions.

The initial categories for investigation dealing with exemplary programs included curriculum, instruction, assessment, evaluation, professional development, and leadership emerged from the literature review. These categories were broken down into their various themes for data analysis. Subsequently, each category is discussed with its corresponding themes along with the appropriate concept map/figure (see Figure 3).

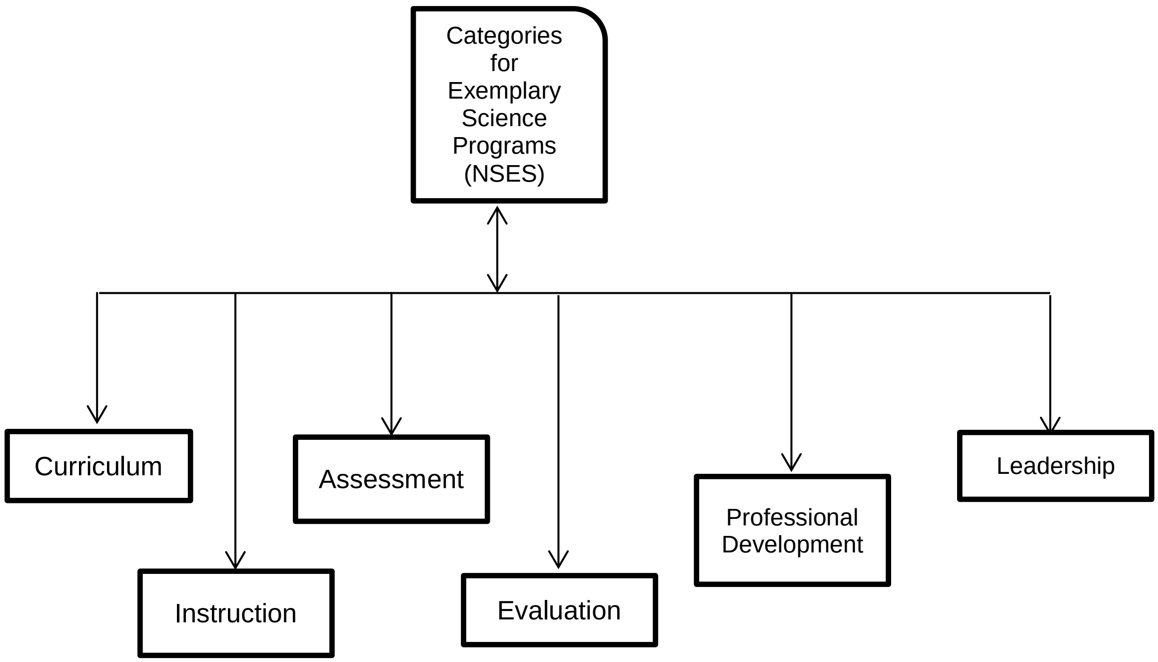

Figure 3. Categories of Exemplary Science Programs as outlined in NSES (NRC, 1996).

Douglas Charter High School Themes

Teachers' knowledge of standards. The science curriculum is nothing new to North Carolina science teachers. The teachers at DCHS use the standards to guide the appropriate content to teach the students and so therefore, teachers were well-informed on the standards. Their familiarity with the standards to guide the science curriculum was pervasive in participants' responses and actions. For example, by using their expertise of the standards, Mrs. Barbour, Mr. Harris, and Mrs. Karrington created student friendly biology textbooks. Dr. Carter mentioned how the teachers enrich the curriculum. Mrs. Whitman and Mrs. Cramer informed the students about the curriculum by displaying the content standards on the board or within power-point presentations. Figure 4 illustrates the theme for curriculum standard (see Figure 4).

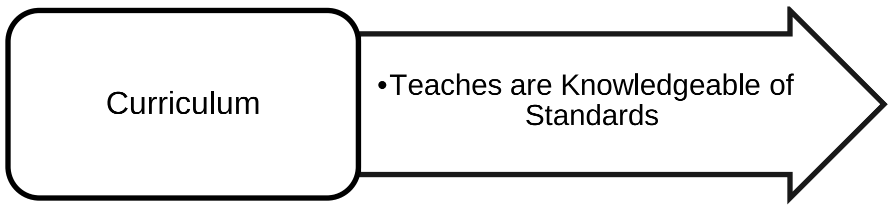

Figure 4. Teachers' Knowledge of Standards Theme.

In the process of understanding how the curriculum in exemplary standards-based science programs were aligned to the *National Science Education Standards* at DCHS, Dr. Carter stated, "Teachers enrich the curriculum, teachers know the state standards; they internalize the standards as a goal to start. The standards are the foundations for a curriculum that help the students develop skills on how to think in science." Mrs. Barbour provided an example of how the teachers use the standards to enrich the biology curriculum. "We have a textbook in biology that we [biology teachers] made. The biology text is just too much to get through in one year so this is a condense version of what we felt is most important. It's our course pack." Mr. Harris further explained, "So it's all printed and then we put it into a binder that the kids could use instead of a textbook. So we narrowed the curriculum and to do that we used the standards and the objectives from the state department to enrich the curriculum for our students." Similarly, Mrs. Karrington added,

> So when the essential standards came, we looked over the essential standards and compared those to what we were already doing and they aligned. We're fortunate to have really motivated students and excellent teachers, so we can cover more than is required by the state. So we are not in a situation where we like, oh no we have to add this into the curriculum. Usually it's like, okay we can see the curriculum is moving towards de-emphasis of this and more emphasis of that and we discuss if we want to make that change as well or do we want to continue to emphasize more.

Mrs. Whitman indicated that she had worked on the State Department Committee for Essential Standards. "I was one of the four physics teachers so I always look back at them."

When asked how the curriculum was extended beyond the classroom in exemplary standards-based programs, Mrs. Cramer emphasized,

> Many learning experiences take place outside of the building on planned "Flex Days," or on traditional field trips. Flex Days allow teachers and students to explore topics in depth and often across disciplines. They occur once each semester over two successive Fridays during which regular classes are cancelled. Students meet for half-day sessions in small groups to pursue projects in science. Groups often travel off campus.

Aware that the classroom is a limited environment, these teachers established relationships with local businesses and industries that allowed them access to their facilities. Mr. Harris shared,

> I am an advisor for the Science Olympiad. We have a science flex and what we do is take them [students] out to an eco-station and we do a classification activity where they're out in a field of an arbor viewing all of the different North Carolina trees. We also take them to a pond right here on site and we teach them how to study the eco health of a pond by examining the little vertebrates. And they're able to look through the pond

> and see what creatures they can find. They count them and get an idea of the health of an ecosystem.

Mrs. Cramer talked about the variety of opportunities that are provided at DCHS,

> We have a Green Club here at school and so a lot of the kids who are concerned about environmental issues do outreach in the community, they have a garden that they've been working on, they have a research project they've been doing at Prairie Ridge. We have a competition group for the Environ-a-thon and it is outside, it's very hands-on, they get to learn about five different areas related to environmental issues. We have a Social Justice club that sometimes talks about environmental issues, climate change.

When observing how teachers align the standards to the curriculum, I noticed how the teachers at DCHS displayed the standards on their whiteboards or within their power-point presentations for students to view. Figure 5 is an example taken from my field notes in Ms. Cramer's class:

> The Living World**: Essential Knowledge: Natural Ecosystem Change**
> (Climate shifts; species movement; ecological succession)
>
> **Objective 1:** Which method of sampling is better for plants? Which is better for animals?

Figure 5. Earth and Environmental Science Standard Example.

Figure 6 is another example taken from Mrs. Whitman's class:

PHY. 1.2 Analyze systems of forces and their interaction with matter.

Objective: Phy.1.2.3 Explain forces using Newton's laws of motion as well as the universal law of gravitation.

Essential Standard: Students should understand how Newton's Second Law, *net m,* applies to an object subject to forces such as gravity, the pull of strings, or contact forces, so they can:
ÂF = F = a
(1) Draw a well-labeled, free-body diagram showing all real forces that act on the object.
(2) Write down the vector equation that results from applying Newton's Second Law to the object, and take components of this equation along appropriate axes).

Figure 6. Physical Science Standard Example.

This excerpt was taken from my field notes that read:

> The teacher pointed to the information displayed on the white board or within the power point presentation and asked the students to record the information in their notebooks as it is read.

Some of the teachers at DCHS read the standards to the students while some of the teachers asked students to read the standards to the class. Teachers frequently referred back to the standards during the lesson to assist students with connecting their learning to the standards and therefore to the curriculum.

In the vision of science education described in the standards at DCHS, effective teachers have the ability to examine and select activities that are aligned to the standards. Lab activities that were observed in this study were relevant to the current curriculum. For example; Mrs. Karrington used the

Strawberry DNA extraction activity to promote learning for students about the process of DNA extraction. The learning outcomes were reflected in this activity as well as the standards to ensure that the students were aware of the expectations for learning as outlined in the standards. This activity was connected to the standards and therefore connected to the curriculum and demonstrated an understating of how scientists use DNA. In the process of internalizing the curriculum, teachers at DCHS devoted less emphasis on rigidly following the curriculum but on using their knowledge and expertise of the standards to selecting and adapting the curriculum to meet the needs of students.

ACTIVE, CREATIVE & SOCIAL (ASC). Instruction is a second category that permeated throughout the standards. This category has the following theme; ACTIVE, SOCIAL, & CREATIVE (see Figure 7). All participants discussed how ASC is utilized in the school, but specially in the science department to promote teaching and learning. Mrs. Barbour talked about how she likes to incorporate many different components of ASC into her classes to engage her students whereas Mrs. Karrigton discussed how she uses ASC to plan lessons that incorporates all of the components. Mr. Harris noted how he specifically uses the CREATIVE component to plan differentiated activities. In addition to the discussions, I observed ASC in action in Mrs. Whitman and Mrs. Cramer’s classrooms.

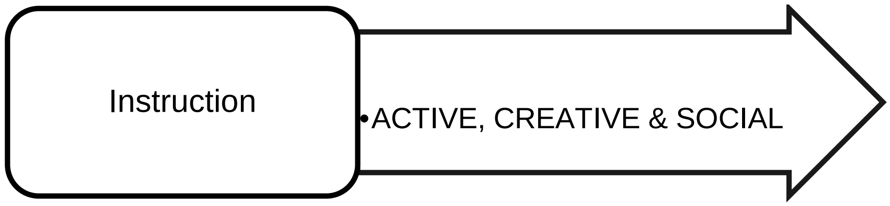

Figure 7. Active, Creative, and Social Theme.

In the process of understanding how instruction in exemplary standards-based science programs were aligned to the *National Science Education Standards*, the phrase I heard again and again from the teachers and the principal in describing the learning environment was “Active, Social, and Creative (ASC)” aspects. These adjectives are used to describe every level of instruction and customs that govern the science department to the fully engaging classroom lessons I observed and heard described.

Active at Douglas means at least two things; (1) students are physically active; and (2) students’ minds are active-questioning, wondering, reflecting. Students are expected to be intellectually active at all times. When I asked Mrs. Barbour how she implements ASC, she reported,

> I like to have at least three to four different opportunities for students to learn instruction during class time. I like to have a mix of things so I can check in to make sure everybody understands what we are doing or have done. Then I like to have some kind of conversation where people get to think about stuff that they haven’t thought of. I have some group discussions, some neighbor conversations (turn and talk), sometimes the students have to listen to me, and other times they have to depend on their own thinking. This is a part of the ASC learning requirement here at DCHS.

The height of this actively intellectual approach is in the ability that Douglas Charter High School fosters in its students to think about their own thinking. Mrs. Karrington furthered explained how she used ASC in her classes,

> The school has a requirement almost. It's called Active Social Creative learning (ASC). So when I am planning instruction or anyone in the department planning a lesson, we think about; Are my kids going to be actively involved? And that can be physically active but it can be mentally active. So like are you going to be creating a lot of cognitive dissonance or perhaps you're providing an activity that requires mental engagement. Socially, there needs to be time for the kids to be talking. It can be a discussion or they just talk to each other. But that's a part of every single science class here at DCHS.

An underlying principle of all the pedagogy at DCHS is the social interactions, as distinct from presentation, lecture, or solo seat work. Students work independently to prepare for intellectual interaction later.

Finally, in addition to the active and social aspect of DCHS's active, social, creative motto is, "the needs of individual students are a focus through creative and differentiated instruction," shared Mr. Harris. The teachers all reported that this type of learning environment is mandated. In discussing how he goes beyond what is mandated to provide his students with the creative learning environment that supports their individual needs, Mr. Harris also reported,

> I am a firm believer that a lot of kids are lost by the traditional note taking, so I don't do that at all. I provide students with all of their typed notes. I don't see any reason for that note taking piece in the traditional sense where they copy off everything. I'm a big believer in varied instruction and so some kids, for example, when you give them something to memorize will do really well but if you give them a poem to write about, they would be crushed into little pieces so you have to be very careful. So all students

> have their different talents and I have them do lots of different things so they can feel successful, I think that help kids a lot.

Most of the lessons observed at DCHS were planned to teach, test, and practice the scientific process skills. These included; hypothesizing about changes; comparing and contrasting, observing, predicting, measuring volumes of liquids, making wet mounts of samples, and calculating, recording and analyzing changes in population. For example one Biology class used indicators to test for the presence of organic compounds, while another teacher used technology and Molecular Clocks to provide a lesson on critical thinking and problem solving.

The teachers planned by providing appropriate and necessary materials for their students. All teachers incorporated technology to enhance their lessons. For a virtual lab on population biology students used the internet for access; the computer to generate graphs and visuals; and to locate additional resources. All teachers provided hands-on materials in at least one part of each lesson. For a group lab: *Identifying Organic Compounds* all materials provided were test tubes, test tube racks, hot plates, brown paper bags, Biuret reagent, Benedict's solution, Iodine solution, and beakers.

In addition to providing appropriate content and necessary materials, the teachers placed responsibility for learning on the students. While observing Mrs. Whitman's Physics class, groups of students were assigned a problem to solve and once achieved; they had to mentor the other students in the class about their problem. “Everyone’s problems must be correct for your group to receive points.” Teachers also moved among the students urging them to discuss what they were doing and what they observed. They provided opportunities for discussion: “What is step two asking you to do before you move on? Are you adding more data?”

The lesson plans used by teachers at DCHS provided a varied of ways for students to learn science. This overlaps with Douglas’ “Active, Social, and Creative” expectations for instruction. By choosing activities aligned to standards, the activities addressed a variety of opportunities for students to explore and engage in the learning of science concepts. As noted in Document A (Ecosystem Sampling Lab, “Cereal Lab,” www.douglascharterhs.org/faculty/lcramer/ Classwork/.../CerealLab.pdf), students were directed to work in groups to discuss how the quadrat and mark-recapture methods worked. They read the activity, wrote individual answers, made calculations, created graphs, shared data, analyzed data, and were encouraged to seek help. This translated into a cultural of varied experiences.

In addition to the reading, describing, calculating, analyzing, graphing and working in collaborative groups found in this lesson, this activity as aligned to standards offered practical experiences for the students. As noted in Document A (see Figure 8), these are real field sampling methods used by ecologists to take measurement of ecosystems for numerous scientific purposes from environmental quality analyses to studies of invasive species. Students were able to experience the work of ecologist in the field.

Name 9/18/2013 Period Cramer 1st **AP Environmental Science 2013-2014**

Ecosystem Sampling Lab (a.k.a. Cereal Lab) (20 pts)

When directed, obtain the following materials:

1. Let's-not-make-a-mess-notebook paper
2. Two cupfuls of cereal (one mixed, one not)
3. Ruler
4. Marker

PRE-LAB!
1. READ entire lab.
2. Describe, in your own words, how the quadrat and mark-recapture methods work. You might check other sources if needed.

Imagination Caps On! The cereal you will be playing with today will represent a community of several different species. Each piece of cereal represents a different organism. Pieces of cereal that share characteristics (same color and general shape) are members of a single species. You will use these cereal organisms to study the mark-recapture method and the quadrat-sampling method of measuring ecosystems. These are real field sampling methods used by ecologists to take measurements of ecosystems for numerous scientific purposes from environmental quality analyses to studies of invasive species.

Post-Lab Questions: (discuss with your group and then write your OWN answers on a separate sheet of paper)

1. Which method of sampling is better for plants? Which is better for animals? Why?
2. What two assumptions does the mark-recapture method make about the population being sampled?
3. What is the effect of a smaller or larger number of recapture samples on the accuracy of a population estimate?
4. What was the effect of the number of quadrats on the accuracy of your population estimate? Explain.
5. In an actual field study, what would determine the number of quadrats used? Be as specific as possible.

MARK-RECAPTURE METHOD *This can be a bit confusing. Be sure to ask for help if you need it* ☺

1) Acquire materials (*SINGLE SPECIES CUP FOR MARK/RECAP*, mixed species cup for quadrat sampling)
2) DO NOT EAT THE CEREAL!!!!!!
3) Imagine that you want to calculate the population of cereal "organisms" in your cup.
4) **Decide what number** of cereal pieces you want to mark, and then **MARK** that number, being sure to **write down** the number that you marked in the data table below. Use whatever marking method seems best to you.
5) Put all organisms back into the cup (or wrapped in your paper somehow) and shake gently. Pour out again and "recapture" a new sample. You could do this by pouring out the whole cup and *with your eyes closed* count the first 5-10 pieces you see (feel).
6) Count and record the number of marked organisms included and the total sample size. Return sample to cup.
7) "Recapture" another sample, then count and record the number of marked organisms and the total sample size.
8) Pour out the contents of the cup and COUNT the TOTAL NUMBER of cereal "organisms" in the cup.
9) Stop, calculate, and answer questions as directed below.
10) Throw out any marked species that are unfit to eat (marker tastes bad).

Calculations for Mark-Recapture Method

$$\frac{\text{number of animals originally marked}}{\text{overall population estimate}} = \frac{\text{number of marked in sample}}{\text{total number of organisms in sample}}$$

Percent Error = [(Population Estimate – Actual Population) / Actual Population] * 100 (may be negative!)

Data Table 1: Population Estimates from Mark-Recapture Method

Mark Sample		Recapture Samples	Total collected that are marked	Total Sample Size for Species	Population Estimate	Percent Error in Population Estimate
Total Number Marked	Total Number (will count at end)	Recapture 1				
		Recapture 2				
		Average of Both Samples				

Figure 8. Document A: Advanced Placement Environmental Science.

Accepting kids as kids. As a consensus with every participant they all understood the importance of using assessments in order to provide feedback on teaching and learning. Everyone spoke of how assessments impacted their classrooms. Mr. Harris, Mrs. Barbour, and Mrs. Whitman provided opportunities for students to critique their work based on their potential. This feedback was also used to inform teaching practices. Figure 9 illustrates the theme for assessment.

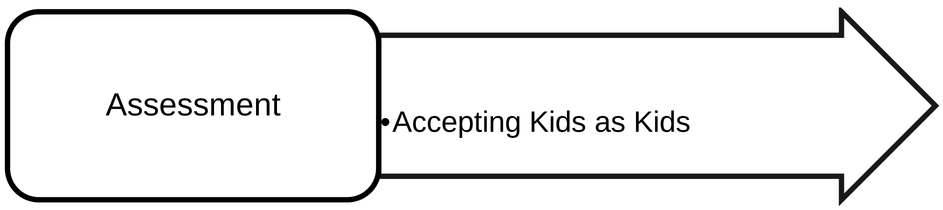

Figure 9. Accepting Kids as Kids Theme.

In the process of understanding how assessments in exemplary standards-based science programs were aligned to the *National Science Education Standards*, students provided assessment data that were aligned to standards at DCHS. All teachers at DCHS reported that assessments “produce feedback.” Mr. Harris provided a homework example,

> Homework might be for the students to go through the standards and on those standards and objectives to mark with a plus, a minus, or a zero; “I feel very strongly I know that”; I feel very strongly I don’t know that,” or I’m kind of iffy on that but I’ve got a feel.” That way for them they know where they’re weak halfway through the unit and don’t need to wait until the end. We actually use this as a teaching document.

Whereas assessment data informed teachers of students understanding of science standards, assessment data also enlightened what was important to learn.

> With every unit, I [Mrs. Whitman] ask for plus delta from the students. I give them four post-it notes. I show them the categories. I ask them to tell me about the test. But I ask them to tell me what was good about this unit? What worked for them? What would they change about the unit? What was frustrating, not helpful? Then I summarize it for them and put it on my website for them to see and or download.

In addition to students producing data that informed teachers about their learning, teachers used assessments as vehicles to improve their teaching. Mrs. Barbour provided an example,

> I have a plus/delta. When I hand back their test with the answer key, I always have them check to make sure I graded everything right and make sure everything's fair. They make mistakes and I make mistakes. I always ask, "What did they do to prepare that really worked? What did they kind of neglect that would have helped?" And for the student and also for me; "What did I do to help the student? What could I have done better?" It's just a way to kind of think over their study methods and my teaching methods. So it's a post-test reflection. So I'm trying to get the kids to advocate for themselves.

Assessments are the primary feedback mechanism in science education. Teachers at Douglas Charter High School discussed using self-assessments. I observed students in an Advanced Placement Biology class self-assessing their Evolution test. The test consisted of the following; multiple choice questions, graphs and diagrams with analysis questions and short answer laboratory questions. Mr. Harris asked the students to reflect on their answers and to work with students at their tables to correct wrong answers. He discussed grading and provided feedback.

In the vision of science education described by the Standards assessments were completed in many different ways. Besides traditional paper and pencil tests, I observed assessments being used in multiple ways. These assessments included; group work, laboratory activities, debates, discussions, calculations, lab reports and self-assessments. As illustrated in Document B (Sign Off-Motion and Force Along a Line) students were allowed to complete the assessment with their assigned groups.

This assessment provided important clues to the students about what was important to learn. As reflected in Document B (see Figure 10), students were expected to use their knowledge of “Motion and “Force” to solve scientific problems; determine the weight of a man on Jupiter with a change in acceleration, calculate the value of the ratio between two different masses and the acceleration of a spring scale at different intervals. The design of this assessment provided the teacher with feedback on how well students were learning the standards and it also provided the students their purpose for understanding the standards.

APC Physics

SIGN OFF – Motion and Force Along a Line Name: ____________________

__________1. If a man weighs 900 N on the Earth, what would he weigh on Jupiter, where the acceleration due to gravity is 25.9 m/s^2?

__________2. An electron of mass 9.11×10^{-31} kg has an initial speed of 3.00×10^5 m/s. It travels in a straight line, and its speed increases to 7.00×10^5 m/s in a distance of 5.00 cm. Assuming its acceleration is constant, (a) determine the force exerted on the electron and (b) compare this force with the weight of the electron, which we neglected.

__________3. A force **F** applied to an object of mass m_1 produces an acceleration of 3.00 m/s^2. The same force applied to a second object of mass m_2 produces an acceleration of 1.00 m/s^2. (a) What is the value of the ratio m_1/m_2? (b) If m_1 and m_2 are combined, find their acceleration under the action of the force **F**.

__________4. The largest-caliber antiaircraft gun operated by the German air force during World War II was the 12.8-cm Flak 40. This weapon fired a 25.8-kg shell with a muzzle speed of 880 m/s. What propulsive force was necessary to attain the muzzle speed within the 6.00-m barrel? (Assume the shell moves horizontally with constant acceleration and neglect friction.)

__________ 5. A 72.0-kg man stands on a spring scale in an elevator. Starting from rest, the elevator ascends, attaining its maximum speed of 1.20 m/s in 0.800 s. It travels with this constant speed for the next 5.00 s. The elevator then undergoes a uniform acceleration in the negative *y* direction for 1.50 s and comes to rest. What does the spring scale register (a) before the elevator starts to move? (b) during the first 0.800 s? (c) while the elevator is traveling at constant speed? (d) during the time it is slowing down?

Figure 10. Document B: Advanced Placement Physics C.

Accepting observations. Opportunities to evaluate practices, skills, and the science department were mentioned throughout this study. Mrs. Barbour discussed having other science teachers in her classes all the time evaluating her teaching practices and providing and appreciating the feedback. Dr. Carter provided feedback to a teacher after an evaluation and the teacher accepted the feedback. Mrs. Whitman's students critiqued assessments by providing feedback on the assessments in order to improve teaching and learning practices in Physics. Figure 11 illustrates the theme for evaluation.

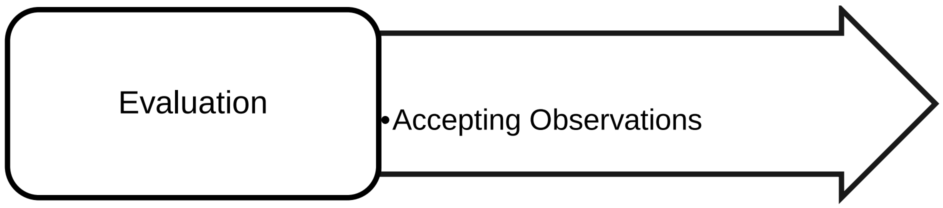

Figure 11. Accepting Observations Theme.

All teachers discussed how they were evaluated daily by their colleagues and by their administrators. The location of the science departments at Douglas Charter High School put teachers in daily informal observation of each other. This in addition to the more formal expectation that teachers observe at least 6 classes a year, created one of the highest cultures of observations that I have ever seen in schools. Many teachers shared that they might be in their classrooms correcting papers while another teacher is teaching, only to be drawn into the lesson. They then talk with their colleague about what they thought worked and what did not. Mrs. Barbour said,

> We are talking to each other all the time. Evaluating, comparing, all the time. It's a lot of pressure. It can be tough to live up to that example, but everyone is helpful. The administration is very involved, not just the two times a year for traditional observation. There is lots of attention to engaged learning. The irony is, I feel like I have more autonomy than I have ever had, yet a lot people are observing me.

The irony of this autonomy in such a collegial environment was also frequently expressed. Many told me they felt great freedom to teach as they see fit. Teachers agreed that this was due in part to the collegial environment.
Mrs. Whitman said, “I have great peers. They know their subject matter and far more, they have worked professionally. They have interesting lives that they share with the students. This is my 47th year. I couldn’t leave this collegial environment.”

The principal monitored the work of teachers in order to promote effective instruction at Douglas Charter High School. I shadowed the principal while he evaluated science teachers. Dr. Carter evaluated one of the participants in this study, while I observed. The evaluation at DCHS lasted 30 minutes. Dr. Carter agreed to discuss feedback after the evaluation. When asked to summarize the evaluation, Dr. Carter stated,

> I observed less teacher directed instruction and more independent, hands-on student led classrooms activities. This is the type of instruction that is expected with the Common Core and Essential Standards.

Dr. Carter met with the teacher during planning time to share feedback from the evaluation. The teacher was receptive to the feedback. The following is an example of their discussion from my field notes;

> Dr. Carter: Ms. X, I observed a lot of group work and was extremely impressed with how structured the activities were and how well equipped and prepared your students seemed to be. Students were able to explain the expectations, and they even

directed me to the objective mentioned on the board. Way to go!

Science teacher: Thank you Dr. Carter for the feedback. I really value the feedback and I expect my students to explain expectations for learning when you, other teachers, and guests are in the room.

There was obvious a focus on aligning expectations for learning to standards at DCHS as well as providing and accepting feedback.

In the science classroom envisioned by the Standards, students need the opportunity to evaluate and reflect on their scientific understanding and abilities. The teachers welcomed feedback and suggestions from students on assessments. Document C represents a Plus/Delta chart from an Advanced Physics C class (see Figure 12). Students were allowed to evaluate unit assessments, preparation and teaching practices. The teacher provided students with post-it notes. They had the freedom to evaluate assessments by writing what they liked or disliked about assessments and how they prepared for assessments. Feedback was accessible on the teachers' website for the students to view. Also, through student evaluations, teachers were provided feedback on the design of assessments and on their teaching methods. As a result, students were treated as evaluators in this collegial environment through this evaluation process.

PLUS/UNIT TEST	DELTA UNIT/TEST	PLUS/YOUR PREP	DELTA /YOUR PREP
Felt Sign Off was helpful/similar difficulty to test ++ ++ + + + + + + +	Add AP questions to practice test ∆∆	Doing Homework/ Checking solutions + + + + + ++ + + + + + + + + + + + +	Do homework? Check it in solution manual ∆ ∆∆ ∆∆ ∆
Felt coverage was fair/ thorough; test reflected material taught+ + + ++++++ +++++++ + +++ + +	AP Problem too confusing/hard ∆ ∆∆∆ ∆∆ ∆ ∆	Explaining to others/ Doing Sign off & Team Quiz for Understanding + + + + + + + + + + + +	Study more/get sleep ∆∆∆
Labs were beneficial/fun ++ ++ + +	Diagrams on test confusing ∆	Looked at labs (concepts)	Make less careless errors ∆ ∆
Test Questions were interesting/familiar + + + + +	Multiple choice on test too hard ∆ ∆ ∆ ∆ ∆∆∆∆ ∆ ∆ ∆	Used YouTube (?) +	Review old problems ∆
Review sheet helpful +	New concepts introduced (?)∆	Used Review Sheet + +++ + + +	Read problems carefully ∆
Practice Test Helpful + ++ + +	Practice test too easy ∆∆	Review test+++++++++++++++++++++ +++	Do practice test ∆ ∆ ∆∆∆ ∆ ∆
Length was good + + + + + + +	Test too long ∆∆∆∆∆ ∆ ∆ ∆	We did good variety of problems + +	Study SIGN OFF ∆∆ ∆

Figure 12. Document C: Plus/Delta Assessment Evaluates.

“No islands.” In addition to curriculum, instruction, assessments, and evaluations, professional development is also a category for exemplary science programs as outlined in the standards. The teachers discussed having “no islands” in the science department at DCHS. “No Islands” meant for Mrs. Whitman to stay connected to ongoing professional development by writing standards and sharing ideas with peers and students. Mrs. Barbour also prevents “no islands” by staying connected to university classes in order to engage students. Most teachers talked about the hiring process with new teachers. Mr. Harold, Dr. Carter, Mrs. Cramer, and Mrs. Karrington discussed supporting new teachers with resources to set then up for success. Even the professional growth plan utilized by the teachers ask them to include individuals in their growth plans to help them from being on an island by themselves, but to encourage success. Figure 13 illustrates the theme for professional development.

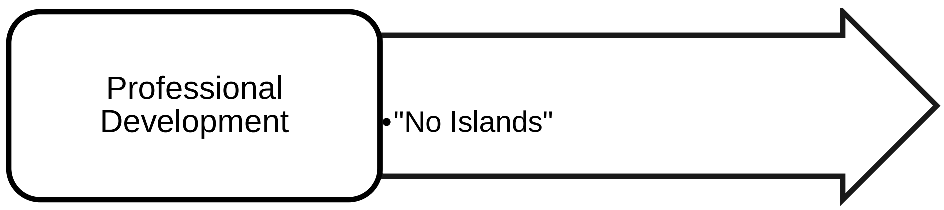

Figure 13. “No Islands” Theme.

In the process of understanding how professional development in exemplary standards-based science programs were aligned to the *National Science Education Standards* at DCHS, all of the teachers discussed sharing science practices and keeping abreast on current science practices. All of the teachers had current training experiences in science content and methods. Mrs. Whitman mentioned “I belong to the American Association of Physics Teachers. I evaluate the online Virtual Public Physics courses. I write assessment questions for the New Essential Standards in Physics.” Majority of the teacher had participated in university level science courses and had attended science conferences at the local, state, regional, and national levels. Mrs. Barbour’s response was, “I have taking university graduate level biology, physical science and earth science courses to keep current. I need to know what everyone else is doing in these subjects to engage students.”

In an effort to support the growth of others, opportunities for professional development was offered for new teachers. Once hired, the principal and the entire science department ensure that care was taken for the new teachers. According to Mr. Harris,

> Our administrator came up with the idea of when you hire eagles you can’t expect them to be chickens. Not everyone starts in the same place or can go at the same pace, and so we are going to support them, bring them along.

The new teachers were provided with a buddy teacher. Dr. Carter believed that “the buddy teachers helped them [new science teacher] set up for success.”

New science teachers arrived early in the beginning of the school year to participate in five full days of professional development that addressed their individual needs and science practices. Mrs. Karrington, reflecting on her experience when she was a new teacher said, “It’s a bit of a baptism by fire, but there is a lot of support.”

However Mrs. Cramer noted that she was very overwhelmed by the experiences at first, but there was a lot of support. “They ease you into it.” However Mr. Harris shared,

> The main thing would not to be an island. If newcomers are making themselves into a little island where they don’t communicate, then they are

> struggling by definition. And so that in other places that's what some schools would like. You're an island. You've got your island protected and you don't have to worry about it. We are just the opposite in that way and there's no island because you're too interconnected with how the program works and you're messing everybody else up even if you're good on an island, and so there's got to be some connection there.

Nearly every science teacher I spoke with shared the enjoyment they felt in working in this type of environment in which everyone work together.

In the vision described by the *National Science Education Standards*, teachers must participate fully in implementing professional growth and developmental strategies for themselves. As demonstrated in Document D (Professional Growth Plan) all teachers at DCHS were asked to reflect on their current teaching practices and experiences (see Figure 14). Categories included; (a) instructional strategies and (b) technology integration. In this effort to help teachers with this endeavor, teachers had an option to include an additional category on their professional growth plans. This was noted in the third category.

Flat leadership. Leadership was the final initial category found in this study as outlined in the standards. There was a sense of flat leadership at DCHS. The principals, teachers, and students were all instructional leaders and therefore this resulted into the flat leadership found within the science department. Mrs. Karrington discussed being an instructional leader in the hiring process and Dr. Carter encouraged this support of all science teachers in this process. I observed comments made by students describing opportunities to be leaders in the school and in science classrooms.

Professional Growth Plan for Teachers

For each of the categories below, please reflect on your current teaching practices and experiences. Then, select a specific goal for the year in each category. As you write your goal, consider: Where will you put your emphasis? What are some specific steps that you will take and include individuals that you may need to help complete the goal (s)? How will you determine if you have reached your goal? You may choose to flesh out your goal with steps you plan to take and/or benchmarks you would like to reach.

1. Instructional strategies for ensuring that we are reaching all students

   I would like to allow students more options to interact in the classroom and to vary my testing methods so that the students will be able to express their command of the subject material in multiple ways. These options may include more project-based activities, labs, take home essays, student-led instruction, and multi-media presentations.

   To assess whether I have reached this goal I hope to accomplish these benchmarks:

   1. Conduct formative surveys after each unit for the students to evaluate both their performance and mine.
   2. Give students one essay topic/test question to prepare in advance before each test.
   3. Offer at least one more project as an alternative to the traditional test (I currently have two projects and 13 tests).
   4. All students will pass the EOC and my class.

2. Investigating and integrating technology that improves instruction
   I would also like to use my website to “flip” a few more units in order to have the students do more laboratory investigations and activities in class. I plan to further investigate the capabilities of Moodle as I expand upon my website and make it more interactive for the students rather than a place to post my lessons and calendar or to generate announcements. On-line quizzes, blogs, and newsfeeds are supported features that I plan to make better use.

   To assess whether I have reached this goal I hope to accomplish these benchmarks:

   5. Flip at least 5 more “lectures.”
   6. Flip at least 5 more lab activities.
   7. Quizzing online through Moodle after flipped homework to ensure student actively participated.

3. Another area of your choice (optional)
   I want to increase the student’s ability to read independently, carefully, and thoughtfully. I plan to accomplish this by demanding strict adherence to written laboratory procedures/ directions, by assigning more reading of current events and scientific articles, and by holding them accountable for material that I have not explained/ discussed verbally by way of reading quizzes.

Figure 14. Document D: Professional Growth Plan.

I also observed instructional practices used by the principal as viewed in emails that supported the environment of flat leadership and teaching and learning. Figure 15 illustrates the theme for Leadership.

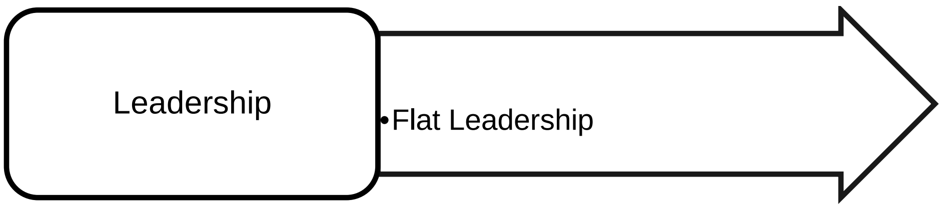

Figure 15. Flat Leadership Theme.

In the process of understanding how leadership in exemplary standards-based science programs was aligned to the *National Science Education Standards* at DCHS, all teachers described leadership as “flat” leadership. In response to this effort, the principals allowed the science department to use their content knowledge and knowledge about the needs of students to make hiring decisions. Mrs. Karrington provided an example of this flat leadership, “At other schools I’ve been in, the principal hires the person and the science department rubber-stamps it. Here the team hires the person and the principal rubber-stamps it. We interview and select the new teacher and the principal supports our decision in this flat leadership environment.”

As a result of sharing hiring decisions with the science department, Dr. Carter explained;

> This process creates a feeling that everyone is responsible for ensuring the success of the newcomers. The teachers know that I believe in their

> leadership and that I am invested in the success of the science department. So therefore we are all leaders. I am a leader in name only. The leadership around here is flat. We all lead.

In this comment Dr. Carter used the word believe ("believe in their"), but the undertone of the comment suggested more. With this comment, Dr. Carter understood the importance of believing in his science department by acknowledging, respecting, and trusting science educators' ability to be leaders in the hiring process. Possessing this trust required a faith that teachers are motivated to do what is right for students.

I observed students take the lead for their learning in all classes. Discussions in these classes were student led; they were not teacher led. Students were expected to read, learn on their own and then drive discussions. Comments from a group of students, explaining how Douglas Charter helps students become leaders, were posted on the outside some of the science teachers' classrooms. Some of the comments that I read,

> Mrs. Karrington's class: It's the class discussions. I can form my own opinions, my own morals. I really know what I stand for now. Class debates help, which we do a lot.
>
> Mr. Harris's class: The teachers really encourage you to step forward. To take a stand. To not hesitate. They really want you to be the best you can be.
>
> Mrs. Barbour's class: My science teacher lets us work with whoever we want. The teacher doesn't just teach but students go out their way to help each other to make sure everyone understands it.

Opportunities for students to form their own ideas and become leaders of their own learning are aligned with the *National Science Education Standards*.

Leaders at DCHS were advocates of the science programs. They monitored the work of the school and the staff while providing corrective feedback that enhanced effective functioning in the science department. Document E illustrate an example of emails sent to the science department from the principal (see Figure 16). This example represents how instructional leadership and standards were utilized to improve science teaching and learning. Through science walk-throughs, leaders set high standards for science teachers' practices of instruction and assessment that resulted in an environment accountable for teaching and learning. They created a culture of shared leadership.

From: Principal
Sent: Wednesday, September 26, 2013
To: Science Department
Subject: This week's Science walkthroughs

Science Teachers,

This week's walkthroughs were good. I observed a lot of you helping individual students and I have to say that this is probably the most inspiring thing I get to observe as I make my rounds. To witness your students getting your full and undivided attention makes me miss teaching deeply… Keep up the good work, your students are watching.

Suggestions/Concerns

-Please make sure that you are completing and displaying your daily lesson plans.

Plusses:

- It is inspiring to see so many of you work one on one with so many of your students, most of these students desperately need that!

Figure 16. Document E: Science Walk-through Feedback

Strengths and weaknesses of DCHS's science department. When teachers were asked which standard is most critical for an exemplary science program or what the strengths of the department were, Mrs. Karrington shared,

> The leadership of the school is probably the most important reason for its success. The principal and the administrators are supportive, they are almost never top/down. They almost never say, "This is what you have to do." Like active, social, creative is the only thing that has to happen, but even that, "This is how we will help you learn that style." Decisions are sometimes painful because we discuss them in-depth and everybody has a say in them. But the formal structure is the department chairs all meet once a month with the administration and they share the concerns of their departments or the administration shares their concerns and then we share those back. The formal communication system is there but people bypass the formal system all the time because Dr. Carter is around, because the administrators are around and you just talk to them. They're visible.

Mr. Harris also shared that leadership was strength for the science department,

> We have a flat leadership model. The principal is trained as a teacher so there is no non-teacher, and so it's a very flat model. The departments basically do the hiring and the principal does an administrative interview with the elected deans to make sure they're feeling okay about that. But generally, it's in conjunction with the department taking the lead on that.

When I asked Mrs. Whitman, Mrs. Cramer, and Dr. Carter to share their thoughts on the strengths of the science department or to discuss which standard was critical for exemplary science programs, all three stated that content knowledge was important. Mrs. Whitman stated, "I just think we have very strong content knowledge. Our knowledge is extremely strong because we really dig in deep to understand what it is that we must teach our kids. I have to have strong content knowledge in order to write assessment questions for the state department."

Dr. Carter shared, "The science teachers enrich the curriculum. They really know, based on their knowledge what should be taught." Mrs. Cramer also mentioned content. "One of the biggest strengths to me is that every teacher loves their discipline area and so excited and curious about the information they're talking about all day."

Finally, Mrs. Barbour shared that "the professional opportunities that we have with each other, the listservs, and workshops, and the professional opportunities that we provide our students within and beyond the classrooms with Flex Days brings strength to our department."

When teachers were asked to share the weaknesses of an exemplary science program, Mr. Harris and Mrs. Barbour mentioned time as a weakness. "I wish we had more time in the day to complete more labs. It's hard to get everything in within a 45 minute time span," reported Mr. Harris. "We need more time in the day and then I could find or make up more discovery type activities. We could still cover the long list of subjects in the AP Curriculum, but also stop and wonder about things more" added Mrs. Barbour.

Mrs. Cramer mentioned the need for more resources. "Sometimes I want something like stronger microscopes or more probes to enhance learning and to differentiate more for the students." Finally, Mrs. Karrington, Mrs. Whitman, and

Dr. Carter all discussed concerns of not finding good teachers to work in the science department when others leave. “Well I’m constantly worried about the fact how replicable it is if some of these really awesome teachers leave to get another awesome teacher and how many of those teachers are out there,” shared Mrs. Karrington. Dr. Carter further explained, “We put a lot of time investing into hiring strong teachers but it concerns me that there are not many strong science teachers out there.” Finding qualified staff also concern Mrs. Whitman. “I have stayed in this job for a very long time. One reason is because I love kids and I love teaching, but the second reason why I have stayed is because they need me. It is so hard to find science teachers out there, especially Physics teachers.”

Summary. In summary, teachers knowledgeable of standards, the ACTIVE, SOCIAL, CREATIVE process, accepting kids as kids, accepting observations, tolerating no islands, and flat leadership were the themes (see Table 16) that emerged from the exemplary science program at Douglas Charter High.

Table16

Themes of Exemplary Science Programs at Douglas Charter High School

Initial Categories as emerged from the literature on NSES	Themes
Curriculum	Teachers Knowledgeable of Standards
Instruction	ACTIVE, SOCIAL, CREATIVE (ASC)

Table 16

(Cont.)

Initial Categories as emerged from the literature on NSES	**Themes**
Assessment	Accepting Kids As Kids
Evaluation	Accepting Observations
Professional Development	No Islands
Leadership	Flat leadership

Jefferson High School Themes

Teachers knowledgeable of content. Like the teachers at Douglas Charter High School, the teachers at JHS understand that the content standards are not a science curriculum. Curriculum is the way content is delivered. It includes the structure, organization, balance, and presentation of the content in the classroom (*National Science Education Standards*, 1996). For example, by being well-informed of the standards to guide the curriculum, Ms. Walter discussed having the autonomy to use the curriculum guides and her familiarity of the standards to create lessons based on the needs of the students. Mrs. Talbert also discussed revising the curriculum frameworks designed by the district to enhance understanding for her students. Mrs. Hilliard displayed standards specific to the curriculum on the board for her students to write while Mr. Harold chose standard specific assignments for his biology class to complete. Mr. Davis discussed how opportunities for students beyond the classroom are standard and curriculum specific to scientific learning. Figure 17 illustrates the theme for curriculum.

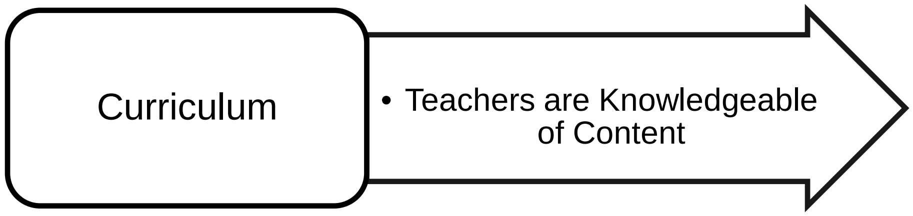

Figure 17. Teachers are Knowledgeable of Content Theme.

In the process of understanding how the curriculum in exemplary standards-based science programs were aligned to the *National Science Education Standards* at JHS, Ms. Walter reported,

> So we use the standards as our basis to inform the curriculum. Mr. Davis sends all teachers an unpacking of the standards document. There are lots of activities, web sites, extensions that you can do with your classes based on those standards or whatever is underneath that topic.

Ms. Hilliard also explained,

> The district’s curriculum overview takes the standards and breaks them down into kind of quarter chunks to help organize teaching. So we use the curriculum overview and the standards to create a pacing guide to help us organize our teaching and help make sense of it for our students.

Standards also inform the curriculum by helping teachers organize the curriculum to focus on the needs of the students. According to Ms. Walter, “We come up with the basic labs we all need to do with each of our classes and then we have the autonomy to fill in activities as we choose based on our students’ needs." Mrs. Talbert furthered elaborated, "Standards for the courses are broken down into essential learning. Learning objectives are paired with science skills and practices. The focus is not just what students know but what they are able to do."

When asked how the curriculum was extended beyond the classroom in exemplary standards-based programs at JHS, Mr. Harold emphasized,

> We have a Science Olympiad Club, Physics Club, Biology club and more. But we also extend the curriculum beyond the classroom by working with students before school, during lunch, and after school with science tutoring. We also provide field trips and invite speakers into the classrooms depending on the standard we are teaching at the time. All of the Earth/Environmental Science classes explore the woody areas behind the school and complete some cool activities.

Ms. Hilliard commented on how the curriculum was extended beyond the classroom, "The Scientific Committee is specifically for high school students. It's not for credit. It's something they do outside of class. It's mostly designed for students in my experience who are really interested in kind of building their science resume."

Mr. Davis explained how a physics teacher takes students to Washington, D.C. to compete in a NASA competition. The students shoot rockets two miles into the air and according to Mr. Henderson, "That's the kind of science program that we have going on," at JHS.

When observing how teachers align the standards to the curriculum, I noticed how the teachers at JHS posted or wrote the standards on their whiteboards for students to view. Figure 18 represents an example taken from my field notes in Ms. Walter's class:

Standard: Bio 2.1 Analyze the interdependence of living organisms within their environments.

Essential Question: *How do we determine population size?*
Objective: *Students will be able to determine mechanisms for measuring population*.

Figure 18. Honors Biology Standard Example.

I could not possibly include all of the content standards that I observed in all four of the science classes at JHS. However, Figure 19 illustrates another example observed in Mrs. Hilliard's class.

Objective: 1 Demonstrate how competition for natural resources in the environment can affect population growth?

Objective: 2 Explain how availability of resources such as food can be limiting for population.

Standard: Bio.3.4.3 Explain how various disease agents (bacteria, viruses, chemicals) and other resources can influence natural selection.

Figure 19. Biology Standard Example.

Ms. Walter and Mrs. Hilliard read the standards to their students at the beginning of the lesson. Students were required to write the standards into their notebooks. Students were also required to put a check beside the objective during the lesson and/or activity when they thought they had mastered today's objectives.

In the vision of science education described in the Standards, effective teachers have the ability to examine critically and select activities to use with their students to promote the understanding of science (NRC, 1996) and make connections. The lesson plans, assignments, worksheets, and lab activities that were observed in this study were aligned to the curriculum.

An example of this is alignment is captured in Document F, “The Lynx Eats the Hare” (Flinn Scientific, Inc., 2010). As illustrated in the document, this laboratory activity is aligned to the *National Science Education Standards*. Given this level of connection to the national standards, it was not a surprise that the students in Mr. Harold’s biology classes were deepening their understanding of scientific concepts. This activity focused on Life Science, interdependence of organism, and behavior of organisms as outlined in the standards which further demonstrated how teachers in exemplary science programs select activities to promote understanding of science concepts as aligned to standards (see Figure 16).

THINK, WRITE, & PROBLEM-SOLVE. Instruction is a second category that permeated throughout the standards. This category has the following theme; THINK, WRITE, & PROBLEM-SOLVE (see Figure 20). I either observed students involved in the thinking, writing, and problem-solving process or the teachers discussed using this processes througout the interviews. Ms. Walter group students together in order to engage their thinking and writing.

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Publication No. 10109

The Lynx Eats the Hare

A Classroom Simulation of a Predator–Prey Interaction

Introduction

Perform this simple pencil and paper simulation of the interspecific interaction between a predator population and that of its primary prey. Students will discover the inextricable link between the two populations in this surprisingly realistic and involving activity.

Concepts

- Predator
- Prey
- Population growth

Materials (for each group)

Flat surface, 12″ × 12″ square
Paper squares, one-inch (snowshoe hares), 300
Graph paper
Paper cutter or scissors
Colored tape or masking tape
Cardboard square, three-inch (represents a Canadian lynx)
Population data table

Safety Precautions

This activity is generally considered nonhazardous. Follow all normal laboratory guidelines.

Discussion

The data is best analyzed graphically. For each animal make a plot of population totals (the first two columns) versus generation number. By plotting the hare population and the lynx population side by side on the same graph, the relationship between the two becomes abundantly clear.

The most evident pattern is the near exponential initial increase in the prey (hare) population followed by a proportional increase in the predator (lynx) population. Students should note the lag time between the two populations. The predator population responds directly to fluctuations in the prey population—recovery follows recovery and crash follows crash.

Students should keep in mind that, as in any simulation (even sophisticated computer models), certain assumptions are made and many variables overlooked. Natural populations are subject to myriad pressures and disturbances such as immigration, emigration, overgrazing, disease, floods, droughts, fires, and extreme cold spells—to name a few. Many of these factors compound each other. Disease spreads more easily as population density increases. Hares intensively competing for food in overpopulated areas will be less able to resist droughts or freezes. The enormous complexity of a relatively simple system is mind-boggling.

If several groups are conducting the simulation, you may wish to introduce other variables. Disease or fire could reduce the hare population at any stage in the cycle. Human hunting or trapping activity could impact either population. Ask the students to imagine the outcome if the lynx were exterminated. Note the well-known impact on deer populations throughout North America—populations no longer regulated by natural predators. Studies have shown that natural predation pressure maintains the overall health and size of prey populations at optimal levels.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Systems, order, and organization
Evidence, models, and explanation

Content Standards: Grades 5–8
Content Standard A: Science as Inquiry
Content Standard C: Life Science, reproduction and heredity, regulation and behavior, population and ecosystems, diversity and adaptations of organisms.

Content Standards: Grades 9–12
Content Standard A: Science as Inquiry
Content Standard C: Life Science, interdependence of organisms; behavior of organisms.

Figure 20. Document F: Biology.

I observed Mrs. Hilliard requiring students to use problem-solving skills to complete a virtual lab whereas Mr. Harold required his students to use problem-solving skills to determine outcomes for predator-prey activity. Students were expected to write down the standards as expectations for learning in Mrs. Talbert class and she also expected her students to use rigorous writing skills to answer questions. Figure 21 illustrates the theme for instruction.

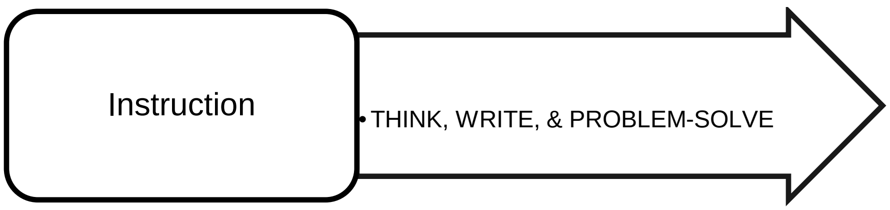

Figure 21. Think, Write, & Problem-Solve Theme.

In the process of understanding how instruction in exemplary standards-based science programs was aligned to the *National Science Education Standards* at JHS, teachers challenged students to THINK, WRITE and PROBLEM-SOLVE. Ms. Walter discussed how she utilized the thinking process in her classes. She stated excitedly, “I love to do stations with my biology students. I put the students that are struggling together at one station, like minds together. The ones that are doing better go around the room to help each other in other stations.” She continued,

> I can spend more time with the students that are struggling to help them focus more and think about their learning. The last station for all students will be “The Ms. Walter station.” So when they come through and do their rounds, their last station is me asking; “Okay, think about what you

> learned, and write down what you learned?" I help each one on a more individualized basis with their thinking and writing.

These teachers were knowledgeable about science and how to help their students learn it. Mrs. Talbert helped her students learn science by reminding them of the standards by writing and engaging them with the standards. She stated,

> I always have an agenda for the day so that the students know what to expect. A part of the warm-up is our objective and our essential questions so the kids always know what the focus is for the class and what they should learn at the end of the period. The agenda just gives them a roadmap of what we're going to do for the day and how to help them engage their thinking.

When asked how they challenged students to accept and share responsibility for their own learning, all teachers mentioned involving students in planning instruction and expectations for learning. Mrs. Hilliard explained, "By allowing the students to help establish the goals and rules." Mrs. Talbert said, "I use lab group jobs and cooperative group rules that the groups decide on." All four teachers mentioned giving the students tasks with timelines. One expression shared by Mr. Harold that described this was "project task sheets that give choices and timelines are helpful. Students have opportunities to pick different task that focus on the writing, the reading, connecting the math, solving problem types of task."

Planning instruction was the cornerstone of science teaching at JHS. The plans provided opportunities for all students to learn science and to be accountable for their own learning. The content of the lessons varied. All were aligned to the standards. The observed time for the lessons varied by the expectations for learning the lesson. Lessons lasted about 60 minutes at JHS.

Most of the lessons observed involved thinking, designing, discovering, testing, writing, calculating, and problem solving. Examples were: designing an experiment to grow two species of the protozoan; discovering the inextricable link between the Lynx and the Hare; experimenting with cereal organisms to study mark-recapture method, quadrat-sampling method of measuring ecosystems; and hypothesizing sample size affecting the amount of error in a population.

Students were expected to use their thinking and problem-solving skills to determine the outcomes for a predator-prey interaction activity in Mr. Harold classroom. Students were expected to use their writing skills to explain the answers to questions about Molecular Clocks in Mrs. Talbert's class. The following is an example of the writing expectation:

> What are the two assumptions made by the molecular clock? Answer in complete sentences and explain how you know that the molecular clock is operating on these assumptions.

Students also had to use their problem-solving skills in Mrs. Hilliard's class to determine how competition affected population growth of two species of the Protozoan, Paramecium alone and together. Many times I heard Mrs. Hilliard say to students, "Stop and THINK about what you are doing!"

Teachers moved among the students urging them to focus and to discuss what they were doing and what they observed in the hands-on activities. This overlapped with the expectations for students to have “minds-on” learning. Too many times I heard teachers reminding students; “Did you check this over with your group? Did you all agree on this answer? However, praise was noted as well; “Awesome Job!” “That’s a great answer.” “That is a great question.” The teachers effectively provided opportunities to challenge their students by providing different experiences and promoting inquiry by expecting students to THINK, WRITE, and PROBLEM-SOLVE.

Taking ownership for students’ successes and failures. As a consensus with every participant they all understood the importance of using assessments in order to provide feedback on teaching and learning. The teachers talked about how assessments impacted their classrooms. Mrs. Hilliard discussed providing multiple ways to assess her students in order to build on their strengths. Mrs. Talbert also provided assessments that promote success for the students. Mrs. Walter assigned a project as an assessment to promote differentiation and success. The teachers all took responsibility for students’ successes and failures, as stated by Mrs. Hilliard, “If they miss the mark, then I missed the mark!” Figure 22 illustrates the theme for assessment.

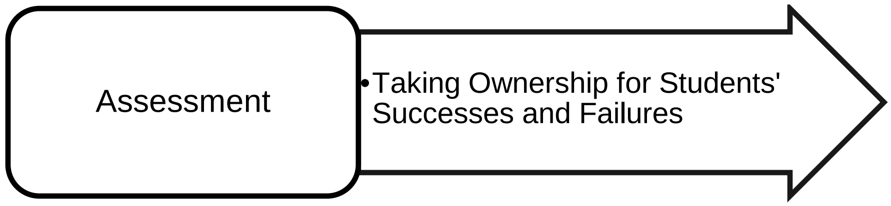

Figure 22. Taking Ownership for Students' Successes and Failures Theme.

In the vision of science education described by the Standards, teachers at JHS used the assessment data in many ways in order to have feedback to improve teaching and learning. Teachers discussed multiple ways of assessing their students that produced feedback that informed instruction. Mrs. Hilliard mentioned the different ways she assessed her students,

> We have quizzes every week so that they [students] can have a small point value checkup, and then I try to give them a variety of other assignments. Sometimes they're physically active, sometimes it's something on paper, sometimes its art, sometimes it is writing. I try to mix it up for their different learning styles and strengths. I also allow them to retest as often as they need if they fail assessments. If they miss the mark, then I miss the mark too and so therefore I have to give them chances to make it better. Then I feel better!

Mrs. Talbert noted how discussions and notebook checks helped with assessing,

> Class discussions are a great opportunity to assess my kids, very informal but very meaningful. So class discussions are really a great tool. I try to be very thoughtful in the kinds of questions that I ask my students to make sure that, you know, I'm really challenging them to make connections. I do notebook checks, and I work with the kids in terms of organization and managing their notebooks. It's amazing what you get from a kid's notebook and how well they're following through with the course and their understanding. I take time out of my class to help them with their notebooks and getting meaning out of our discussions because if they fail, I failed teaching them.

In the vision of science education described by the Standards, assessments were completed in many different ways. Besides traditional paper and pencil tests, I observed assessments being used in multiple ways at Jefferson High School. These assessments included; group work, laboratory activities, debates, discussions, calculations, lab reports, self-assessments, and projects. I observed an assessment presented to students in a Biology class. This assessment was a take home project in which students had to design an ad campaign to bring awareness of human impacts on the environment. The students' role was to create a tri-fold brochure, commercial/Animoto or a play/speech/Prezi.
Ms. Walter reviewed the required information that must be included with each resource in order to receive all points. She clearly established expectations for being successful on this project. The design of this assessment provided the students with feedback on expectations for learning and the assignment also provided the students the purpose for understanding the standards.

Students were assessed in multiple ways by their teachers in the classes at JHS. The teachers provided different assessments as a way to ensure success for all students. Students were allowed to retake assessments in all classes because if they failed, the teachers stated that they failed to teach them.

Taking ownership of observations. Opportunities to evaluate practices, skills, and the science department were mentioned throughout this study at JHS. The principal and the students provided the teachers with feedback on their practice and as a result, teachers took ownership of this feedback from observations. Mr. Harold suggested taking ownership for his observations as way to keep current with his craft. Mr. Henderson email feedback on classroom observations to all science teachers and teachers take ownership of this feedback. Ms. Walter mentioned taking ownership of observational feedback from stakeholders. Whereas Mrs. Talbert takes ownership for observations by her students with feedback on assessments. Figure 23 illustrates the theme for evaluation.

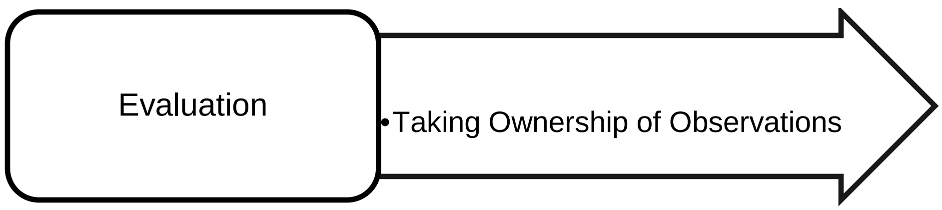

Figure 23. Taking Ownership of Observations Theme.

In the process of understanding how evaluations in exemplary standards-based science programs were aligned to the *National Science Education Standards* at JHS, Mr. Harold commented, “The administration walk in any time they want and I’m fine with that. They give me feedback and suggestions, and I use this information to improve my craft.” Mr. Henderson mentioned the weekly updates that he emailed science teachers while also providing them with feedback of walk-throughs. “I ask specifics; Why?, share concerns, provide suggestions, and give shout-outs. This process helps build relationships with the teachers.” Ms. Walter acknowledged how this daily observations from administration is a good thing but nerve wracking as well.

> We have walk-throughs, five minute walk-throughs every single week. So somebody is always in the room, which is sort of nerve wracking. You have to be on point but also at the same time it's a good thing because it leads to positive interactions with the principals and I need and want the feedback.

The principals monitored the work of teachers in order to promote effective instruction. I shadowed the assistant principal while he evaluated science teachers. He evaluated one of the participants in this study, while I observed. The evaluation at JHS lasted 45 minutes. The assistant principal agreed to discuss feedback with me after the evaluation. When asked to summarize the evaluation, Mr. Henderson stated,

> The agenda items and the essential questions were communicated along with expectations for completing the pollution lab. That was good for the students because the students must understand expectations for learning.

One can assume from this response that there was a focus on science instruction that supports teachers aligning expectations to standards and involving students in this process at JHS. Mr. Henderson also met with the teacher to share the feedback. The teacher stated in the post-evaluation meeting, "As always Mr. Henderson, I welcome your feedback. Even though I am at the end of my teaching years, I continue to want to be the best science teacher that I can be. The kids deserve the best know matter how long I have been doing this!"

In the science classroom envisioned by the Standards, students need the opportunity to evaluate and reflect on their scientific understanding and abilities.

The teachers welcomed feedback and suggestions from students on assessments. Mrs. Talbert noted, “Our students observe us every day.” Students were allowed to evaluate unit assessments, preparation and teaching practices in her classes and other classes as well. An example of feedback on a Biology test from Mrs. Talbert’s class was posted on her website. The feedback included,

- Test problems too confusing
- Test too long
- Felt the coverage was fair/thorough & the test reflected what was taught
- Labs were beneficial
- Practice test was helpful
- Homework problems were aligned to test
- Class discussions were beneficial
- I like getting partial credit
- Good repetition of concepts

This evaluation process provided a collegial environment between teachers, principals, and students. Teachers took ownership for feedback that they received during observations and they used the feedback to enrich teaching and learning.

“No independent contractors.” “No Independent Contractors” at JHS meant that teachers are not allowed to work in the science department alone. Teachers looked for professional development opportunities in order to share ideas with each other, to support each other, and to stay in touch with the world of science. Ms. Walter, Mrs. Hilliard, and Mrs. Talbert discussed staying abreast with professional development opportunities in order to stay connected with science practices and to support the growth of the science department. Mr.

Henderson discussed how all teachers create professional learning environments to ensure that their students do not work alone. The professional growth plans provide opportunities for teachers to be leaders and to look for opportunities to help and support others in science. Figure 24 illustrates the theme for professional development.

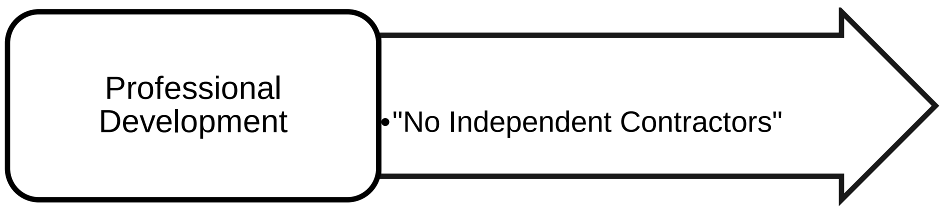

Figure 24. “No Independent Contractors” Theme.

In the process of understanding how professional development in exemplary standards-based science programs were aligned to the *National Science Education Standards* at JHS, teachers reported that they do not allow anyone to work alone. Mr. Henderson stated,

> You will not find any independent contractors working in this science department. Teachers receive professional development opportunities and they are so eager to share. Teachers also design their classes in order to help their students work in a professional learning community. They do not want their kids to work as independent contractors.

Four teachers said they had attended summer institutes in the district and in the state. Ms. Walter shared an example, “I went to the Biotechnical Conference and the Bright Institute at North Carolina Central University.”

Mrs. Hilliard indicated that she had attended the science academy program at Duke Clinical Research Institute. All of the teachers that teach Advanced Placement science classes discussed participating in the Advanced Placement workshops during the summer and being on the Advanced Placement list Serv." I get ideas and share ideas with my colleagues here and with my friends on the online AP list serv. There are so many great ideas. The more I know the more I like to share. My colleagues need to know too" shared Mrs. Talbert.

When teachers were asked to share other opportunities to participate in professional development, teachers discussed the opportunities to work in research laboratories. Mrs. Talbert expressed,

> I worked in two research labs – Chesapeake Biological Research Lab and I did a study on chain expression with birds that were exposed to the chemical called PCP, trying to look at how it affected oxidation within the birds and then I worked at the University of Maryland. I worked in one of their biology labs this summer and I looked at mutations and yeast and how that affected like the frequency of frame shifts and genetic mutations. Things like that. I look forward to sharing this knowledge with my students this year.

Mrs. Hilliard shared one research opportunity,

> I participated in the Kenan Fellowship. I was placed at North Carolina State University working with an entomologist, studying fruit flies but the first part of it was just kind of learning about different bug species. And then the goal of the program is to have like a real research experience and then from that create lessons that are related to the curriculum but that are much more hands-on and help the students relate to what real scientists are doing. These opportunities help me share knowledge of what I have learned with the students and staff in the department but this expectation also helps me to provide the community of learning that the students need to be successful in science. We learn together.

So therefore, all teachers were observed working in stations within collaborative groups to ensure no independent contractors. Students were presented with the following scenario in a biology class as a warm-up activity: As an inquiring scientist, you want to find out whether soap can affect flower growth. You will need to set up your experiment (using the control group and the experimental group) and publish your findings which included; write your hypothesis; describe your control group and your experimental group with regards to variables; create a data table; and make calculations. Students worked in professional learning environments designing experiments, supporting ideas and questions while using the scientific skills to complete the activity.

Many times I heard teachers reminding students; “Describe what exactly is being tested.” “Why do you need a control group?” and “Analyze your data.” Students were heard asking questions within their professional learning environments: “Let’s check our data to see if our hypothesis is correct.” “Do you agree?” Students were provided opportunities to be leaders of their learning.

Teachers participated fully in implementing professional growth and developmental strategies for themselves and for others. Teachers were responsible for designing and implementing ongoing professional development opportunities needed to enhance their skills in teaching science. In order to ensure that new teachers are not left to seek professional development on their own, a teacher leader in science welcomed professional development opportunities to mentor new teachers. As demonstrated in the following

Professional Growth Plan in Figure 25, all teachers at JHS were asked to reflect on their current teaching practices and experiences. A snapshot from the professional growth plans at JHS included; (a) science-instruction, and (b) science-teacher leadership. *Each goal and action plan together should answer the following questions.* What do I want to change about my science instruction or leadership that will effectively impact student learning?

1. What is my personal learning necessary to make the change?
2. What are the measures of success?

Science	**Science Teacher Leadership**
For this school year, I will improve writing instruction in my science classroom by implementing and reflecting on strategies learned during a summer writing workshop for teachers. I'll incorporate writing strategies for describing observations, explaining scientific phenomena, explain cause & effect occurrences, and drawing conclusions from experiments. Indicators of success will be student work samples, analysis of student's writing products, and self-reflection.	This school year, I will learn best practices for mentoring new teachers in my building. I will participate in the district study group and Cognitive Coaching PD and attend an on-line course for mentoring teachers. Evidence of success will include district PD certificate, course completion certificate, mentee teacher surveys, self-reflection on mentoring opportunities.

Figure 25. Example of Science Professional Growth Plan as Aligned to Standards.

Leadership within the school. Leadership was the final category found in this study as outlined in the standards. The administration at JHS was supportive and promoted growth at JHS. They were also very responsive. In addition to being supported, teachers, students, and the principals were all leaders. They shared in the responsibility of advocating for the success of the science department. Mrs. Hilliard talked about having the opportunities to hire new instructional science leaders to teach. Whereas Mr. Harold discussed having students as leaders in the classroom. As an instructional leader for science, Mrs. Talbert advocates for the department on the school improvement team and Ms. Walters looks forward to the feedback from all of the instructional science leaders; including the students. Figure 26 illustrates the theme for professional development.

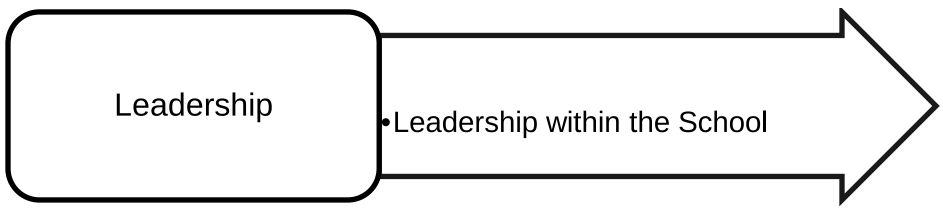

Figure 26. Leadership within the School Theme.

In the process of understanding how leadership in exemplary standards-based science programs were aligned to the *National Science Education Standards* at JHS, the teachers discussed how all stakeholders enact leadership as aligned to standards. They provided responses such as, “Leadership is supportive as opposed to top down,” “They’re extremely responsive,” They are very approachable if you have concerns,” “They support and encourage growth,” and one last comment about leadership contributed to the vision, “I feel like we know what the general direction of the science department is and what we’re trying to do.”

In the vision of science education described in the Standards, clearly defined leadership at the school level is required for an effective science program. Leaders can be vested in a variety of people, including teachers, science coordinators, and school administrators. Mrs. Hilliard stated, “We are expected to be leaders here at JHS. We hire new instructional leaders to teach our kids, we make decisions on what is best for the school and specifically what is best for our departments.” Mr. Harold mentioned, “We even allow our students to make classroom decisions and expectations. They have a say in teaching and learning in the classrooms.”

Mrs. Talbert discussed representing the science department by being a part of the school improvement team. Mrs. Talbert shared, “I always inform the SIT on the needs of our department. As an instructional leader for science, I am always going to advocate for my craft and for my students.” Ms. Walter talked about the support and feedback she receives from the instructional leaders in science. “As a new teacher, I am grateful to have the expertise of all of the instructional leaders around me giving me advice, support, and feedback to make me a better teacher. My students are even growing in this area.”

The principals at JHS were advocates of the science program. They monitored the work of the school and the staff while providing corrective feedback that enhanced effective functioning in the science department. Document G illustrates an example of emails sent to the science department from the assistant principal (see Figure 27). This example represents how instructional leadership and standards were utilized to improve science teaching and learning. Through science walk-throughs, leaders set high standards for science teachers' practices of instruction and assessment that resulted in an environment accountable for teaching and learning. They created a culture of shared leadership.

From: Principal
Sent: Tuesday, October 8, 2013
To: Science Department
Subject: This week's Science walkthroughs

Science Team,

This week's walkthroughs were great. Although I was out of the building 3 of the 5 last this past week and was not able to make it into every classroom, I was impressed with the ones I did visit. Attached are pictures from a few of the classes I visited. One picture illustrates Dr. ____'s physical science students working on ionic compound puzzles. Picture 2 shows Mrs. ____'s class working on a temperature lab involving boiling water. The same day I took the picture from Mrs. ____'s class, I observed Dr. ____'s class melting ice using the exact same methods—I thought that was very cool and that it spoke directly to the collaboration and group planning that is going on with the Chemistry PLC. Picture 3 is one of my favorites. It illustrates a group of students in Mr. ____'s AP Chemistry class going over a very complicated 5 step formula. Students were instructed to solve the formula and had to pick up from where the last group member left off as soon as Mr. ____ would call "time!" which occurred about every 20-25 seconds. The purpose was to make sure that every group member could thoroughly explain what the entire group worked on together. Lastly, Picture 4 shows a student from Ms. Hillard's class writing her groups information on the board from a genotypes and phenotypes activity that involved student rolling dice with the intent of checking for probabilities.

I would like to lift up Dr. _____ for his leadership in working with the students that qualified for the national finals in the Team America Rocketry Challenge. I believe that your guidance and expertise will have these student primed for a deep run in this competition.

Suggestions/Concerns:

Make sure that we are planning bell to bell instruction.

Plusses:

Some of you do a FANTASTIC job with sending home weekly updates regarding the upcoming events in your classes. You can never communicate too much with your parents. Great Job!

Figure 27. Document G: Science Walk-through Feedback.

Strengths and weaknesses of JHS's Science Department. When teachers were asked which standard is most critical for an exemplary science program or what the strengths of the department were, Mr. Davis, Ms. Walters, Mr. Harold, and Mrs. Talbert stated that professional development was critical for the science department. Mr. Davis shared, “We have really amazing teachers with amazing science backgrounds. Most of our science teachers have on-going research backgrounds and they are willing to share this knowledge with everyone. The students really benefit from this knowledge.” Mr. Harold also referenced background of teachers as strength for the department. He shared, “Most of our teachers have had fairly good education credentials and science background besides just science education. We also have had research experiences so we are always sharing or seeking ways to stay updated on current research practices.”

Ms. Walter and Mrs. Talbert thought professional relationships and professional development opportunities were critical for exemplary science programs. Ms. Walter shared,

> I think our strengths are our professional relationships. We work well together by sharing ideas, not afraid to challenge each other, and we encourage one another to do our best. We all are always learning so therefore we are not afraid to ask questions to dip into others’ bags of resources and ideas.

Mrs. Talbert further explained, “Teachers here at JHS are extremely professional. They are well planned and well organized. I enjoy attending our professional learning communities in order to share ideas, design lessons, and to discuss ways to improve our department.”

Finally, Mr. Henderson thought content knowledge was critical for the science department whereas Mrs. Hilliard thought leadership was strength.
“We have an awesome group of teachers in the science department. These teachers really know their craft, they really know their content,” stated Mr. Henderson. Mrs. Hilliard shared, “Our administration, especially the assistant principal constantly gives us instructional feedback daily to help us improve as teachers. They believe in who we are as science teachers and so we are able to make decisions for the science department with their support. This is important for me because I like to know how I am doing.”

When teachers were asked to share the weaknesses of an exemplary science program, Mr. Davis and Ms. Walter discussed having access to more supplemental resources. “I try to gather unwanted resources from all of the teachers that I serve and give them to teachers that are in need of more. We have amazing teachers in these schools however these teachers too need additional resources to enhance their practices and to engage the students,” stated Mr. Davis. Ms. Walter shared,

> In terms of things where we could improve, I think our improvements lie in the ability to have supplemental materials and we could really use more biology textbooks, more earth science textbooks, more online resources or having ability to use the computers whenever we need it. Right now we’re limited in terms of computer space. We have the library, a computer lab and then a couple of laptop carts, and so those can go really quickly in terms of having access to things. Because I would love to do more interactive games and online activities with all of my classes but because there’s a limit you have to sign up at least a week in advance on those. So that can be limiting. I think we can improve in that regard.

Mr. Harold, Mrs. Hilliard, and Mr. Henderson thought that the fear of not having highly qualified teachers available to replace those that leave would bring a tremendous weakness into the department. “My fear is feeling in the hole with good teachers when others leave to pursue other opportunities,” reported Mr. Harold. Mrs. Hilliard shared,

> My biggest concern is teacher turn-over rate. So many great teachers are leaving because better opportunities are provided for them especially for those who have higher degrees and research experiences. Then the rest of us that are left in the science department have to pick up the pieces when they leave and pray that we get some body as good or better to replace them.

Mr. Henderson further explained, “We spend a lot of time in the summer to make sure that we hire the most highly qualified individuals for our students. However due to the economy these amazing people leave because with their credentials, they can make more money doing other things. Finally, Mrs. Talbert discussed,

> We need more time to teach Advanced Placement students especially when we bring in non-traditional students into these classes. They’re going to need that time. We teach these classes on a block schedule. We need to teach these classes year long. Otherwise the students are going to walk away thinking they are not smart enough and can’t do the work and it’s not that at all. They’re really not given the amount of time that they need.

Summary. In summary, teachers knowledgeable of content, the THINK, WRITE and PROBLEM-SOLVE process, taking ownership of student successes and failures, taking ownership of observations, tolerating no independent contractors, and leadership within the school were the themes (see Table 17) found in the exemplary science program at Jefferson High as outlined in the standards.

Table 17

Themes of Exemplary Science Programs at Jefferson High School

Initial Categories as emerged from the literature on NSES	**Themes**
Curriculum	Teachers knowledgeable of Content
Instruction	Think, Write, and Problem-Solve
Assessment	Taking Ownership of Student Successes and Failures
Evaluation	Taking Ownership of Observations
Professional Development	No Independent Contractors
Leadership	Leadership within the School

Cross Site Analysis

Case study research involves an on-going process. The initial categories for investigation of exemplary science programs and instructional practices emerged from the literature review. Through this initial process, a framework took shape. A matrix of categories was formed from each of the data sources: interviews, observations, and documents collected at the sites. This process was similar to the one reported in Miles and Huberman (1984). As Merriam (1990) suggested, the categories outlined served as augmented ideas and tools for further discovery, not as a device to confine the data.

The initial framework categories dealing with exemplary programs included curriculum, instruction, assessment, evaluation, professional development, and leadership was adjusted as themes evolved from an analysis of the data. Curriculum became a culture of expectations for learning, instruction became a culture of varied experiences, assessment became a culture of continuous feedback, evaluation became a culture of observations, professional development became a culture of continuous learning, and leadership became a culture of shared leadership (see Figure 28).

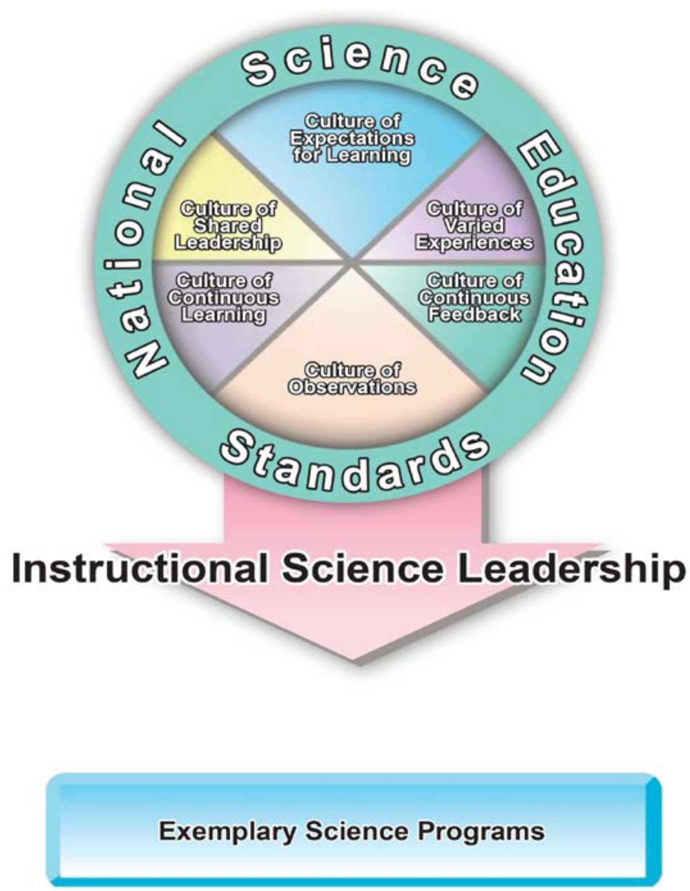

Figure 28. Exemplary Standards-Based Science Programs.

The similarities of the two sites are discussed in some detail in this section. Information that was revealed in the review of the literature and utilized in the construction of the conceptual framework was compared with the themes that emerged from the study. The description and analysis of the two exemplary standards based science programs formed a basis for indicators of exemplary science programs.

Culture of shared leadership. All participants discussed how leadership was supported and shared among all stakeholders which created a culture of shared leadership in both sites. The principals supported leadership in science teachers. They engaged the science teachers and their students in working together towards a shared purpose. They respected the new and different ideas and strategies implemented by the teachers in the science department. They also valued the experiences and skills of the teachers as instructional leaders.

The principals involved teachers in making decisions for the science department. Teachers provided input on scheduling science classes and determining who will teach these classes. Teachers took the instructional lead in determining the needs of the science department in order to improve teaching and learning for all students.

Teachers set parameters that established leadership as a partnership with their students. Students learned together while observing how others were also progressing. As instructional leaders, students would voluntarily help each other. As a result, they shared in the decision making of their learning while taking responsibilities for the learning and growth of their peers. Teachers encouraged responsibility and accountability from all students in the teaching and learning process.

Culture of expectations for learning. All participants in both settings were aware of the curriculum, standards and knowing the content. They discussed how they internalized the standards in order to narrow the curriculum. Students were made aware of the standards as expectations for learning. This was observed in most teachers classrooms as standards were written on the board for students to be aware of expected outcomes. Expectations for learning were written on all the lesson plans and lab activity sheets collected during the study. The principals also mentioned how the curriculum was connected to standards and how teachers shared this expectation for learning with their students while observing and evaluating science classrooms.

Participants discussed the various clubs, field trips offerings, and opportunities to gain additional help in science if needed before, during or after school. Barbour, Cramer, Harris, Karrington, Whitman, and Carter even discussed the Flex-Days for students to tap into their interest of science at DCHS. Connecting the curriculum to standards, extending the standards beyond the classroom, and being aware of expected outcomes created a culture of expectations for learning at both schools.

Culture of various experiences. All participants discussed the various instructional strategies used to enhance teaching and learning for all students and Barbour, Cramer, Karrington, Whitman, Hilliard, Talbert, and Henderson discussed using rigorous instructional practices to facilitate learning. All participants at DCHS utilized the active, social, and creative instructional practices to engage students during instruction. I also observed these transitional practices while observing Hilliard and Talbert's classes at JHS. The thinking, writing, and problem solving process provided opportunities for teachers to challenge students at JHS, which encouraged student driven instructional practices. "By offering opportunities for the students to plan and design their own investigations makes them accountable for instruction," was a response from Talbert. "Group activities require decision making and collaboration among the members of the group," mentioned Hilliard. All participants spoke to the collaborative environments found in science classrooms. This expectation was observed during the lessons and reflected in the directions that were written in the collected documents.

Karrington, Carter and Harold did not discuss discovery activities however the other participants discussed the various ways of implementing scientific inquiry skills. Cramer proposed that "three-fourths of the available time is used for active investigation and one-fourth is used for making hypotheses and conclusions." All other teachers and even one principal concurred that was about what they did and observed in all classes. This was also reflected in all of the documents. All of the instructional practices at Douglas Charter High School and Jefferson High School created a culture of varied experiences at both schools.

Culture of continuous learning. Participants discussed participation in science workshops in order to continue professional growth in science. However, the principals discussed the strong involvement in science among the teachers in these exemplary science departments. One principal described the actions of Cramer, “She attends everything that comes along.” The other principal said that Hilliard “attends many workshops, institutes, and conferences.” However all participants did mention sharing of ideas in professional learning communities. Hilliard and Talbert mentioned conducting workshops with other teachers within the district and within the science departments to promote growth. Davis stated, “A responsibility as district science coordinator is to plan and implement staff development for the district.” Cramer indicated that she had written standards for the state department in addition to Barbour, Harris, Hilliard, Talbert, Walter, and Davis acknowledged using their Professional Growth Plans as a vehicle to improve their practice and to enhance the science departments at both schools.

Barbour, Cramer, Harris, Hilliard, Talbert, Walter, and Davis also implemented professional learning communities among students in their classrooms “by asking for suggestions, accepting ideas, and contributions,” shared Harris. The others indicated that they do it through decision making and choices. All of the professional development opportunities in these exemplary standards-based science programs at DCHS and JHS created a culture of continuous learning for all stakeholders.

Culture of continuous feedback. All participants noted using self-assessments as feedback mechanism. Carter said, “the self-assessments help inform if there is concern before it becomes a problem.” Barbour, Cramer, Harris, Whitman, Carter, Harold, Hilliard, Talbert, and Henderson indicated that assessments are used to inform teaching and learning. Barbour mentioned, “Assessments are used to determine if the students are learning and if I am teaching correctly.” The others agreed with this explanation. The various assessments created a culture of continuous feedback at both schools.

Culture of continuous observations. All participants discussed principals as well as peers observing daily to critique and promote instructional practices. All participants discussed how peer evaluations help guide teaching and learning to “help determine if content needs to be retaught in a different manner,” shared Karrington. All provided opportunities for students to evaluate their learning. This was reflected in student assessments, evaluation sheets, and therefore supports a culture of observations.

The Standard Perceived to be the Most Critical for Exemplary Science Programs

Participants were asked which standard is perceived to be most critical for an exemplary science program (see Table 18) and Barbour, Carter and Henderson stated that knowledgeable of science content was the most critical; “Most of our candidates or our teachers have good subject knowledge,” “Most of our teachers have fairly good education credentials and science backgrounds besides just science education”, "A lot of us have research experiences and so forth." Harris, Karrington, and Walter thought shared leadership among all stakeholders impacted exemplary science programs; "The leadership of the school is probably the most important reason for its success," "We have a very flat model. Leadership is shared." "Our leaders support and encourage growth."

Table 18

Category Most Critical for Exemplary Standards-Based Science Programs

Participants	Content (Curriculum)	Instruction	Assessment	Evaluation	Professional Development	Leadership
Barbour	✓					
Cramer					✓	
Harris						✓
Karrington						✓
Whitman					✓	
Carter	✓					
Harold					✓	
Hilliard					✓	
Talbert					✓	
Walter						✓
Davis					✓	
Henderson	✓					

The others teachers identified professional development experiences as being influential in making their science programs exemplary. Examples of their responses that highlighted professional development were: "With the Einstein workshop. You focus on the nature of science, how we saw what we did in the lab, how that relates to the gap in the classroom, and how we can begin to bridge that gap." Another shared, "We meet as a science professional community once a month to think about some things that our kids are missing or some skills that they need and how we can better address those needs." As one put it, "We get together as a science community once a month and discuss the science curriculum and we have these conversations as to what we could be doing to improve and getting kids to think more like scientists."

Summary

This study found that exemplary science programs, as expected, reflected the *National Science Education Standards*. The teachers in these programs had professional degrees beyond undergraduate degrees, attended professional development workshops, and actively participated in research experiences. These experiences included college level science classes and school, district and national level workshops. They collaborated with their colleagues and with their students by discussing and sharing new practices and ideas and by allowing students to be advocates of teaching and learning. Students were able to use their knowledge of science to solve problems, design experiments, make decisions, collect data, test ideas, and analyze results. The recent report, *Preparing Teachers* noted that,

> there is a clear inferential link between the nature of what is in the standards and the nature of the classroom instruction. Instruction throughout K-12 education is like to develop science proficiency if it provides students with opportunities for a range of scientific activities and scientific thinking, including, but not limited to: inquiry and investigation,

> collection and analysis of evidence, logical reasoning, and communication and application of information. (NRC, 2010, p. 250)

These programs also reflected the standards through instructional support received from principals and the community. The principals supported scientific environments by being visible and by providing instructional feedback to assist teachers with goals for teaching science. Teachers extended teaching and learning beyond the world of the classroom by visiting Eco-Labs, competing in NASA competitions, and offering engaging clubs such as, Science Olympiad, Environ-thon, and Scientific Committee.

Finally, the teachers also reflected on the standards through their awareness and understanding of the state standards. Planning and assessments were structured purposefully to provide lessons that facilitated learning. Teachers assessed learning while the students did the work of learning because "instruction encompasses the activities of both teachers and students" (NRC, 2012, p. 250). The next chapter will discuss findings, implications, limitations, and recommendations for further research.

CHAPTER V

DISCUSSION AND CONCLUSIONS

Introduction

In the preceding chapter, the presentation and analysis of data have been reported. Chapter V consists of a summary of the study, discussion of the findings, implications for practice, limitations of study, recommendations for further research, and conclusions. The purpose of the latter sections is to expand upon the concepts that were studied in an effort to provide further understanding of standards on possible influence on instructional leadership practices and to present suggestions for further research targeting the understanding and impact of standards on exemplary standards-based science programs.

Summary of the Study

This chapter begins with a summary of the purpose and structure of the study and is followed by the major findings related to the *National Science Education Standards*. Conclusions from the findings of this study are discussed. Finally, implications for practice and recommendations for further research are presented and discussed.

Through this qualitative case study it was hoped that insight would be gained in the ways that science teachers in exemplary science programs used and practiced the *National Science Education Standards* in two different settings and how instructional practices impacted these science programs. The standards described what these exemplary teachers of science understood and was able to do. Having a clearer picture of how and why these teachers taught science in an exemplary manner could benefit the science education community. These exemplary science programs have been recognized by having teachers within these exemplary science programs who have received The Presidential Awards for Excellence in Mathematics and Science Teaching (PAEMST) awards and have also been recognized for possessing the qualities set by the *National Science Education Standards*.

Research Questions

The over-arching research question for this study was: What impacts have instructional leadership and science standards had on the success of exemplary standards-based science programs? The major findings presented in this chapter address the following four research questions posed as the purpose of this study:

1. How is science leadership exhibited in a standards-based program?
2. How are instructional practices, curriculum, and professional development aligned to science standards and supported in order to establish and achieve high expectations for students in science?
3. How does aligning assessments to science standards and evaluating standards-based science programs impact student learning?
4. Which standards are perceived by science educational leaders as most critical for an exemplary science program?

In this chapter, a brief overview of the findings from this study is provided including a discussion of the themes and sub-themes. The conceptual framework for this study is drawn from the six standards of the *National Science Education Standards*. Standards for science teaching (instruction), standards for professional development for teachers of science, standards for assessment in science education, standards for science content (curriculum), standards for science education programs (evaluations), and standards for leadership which guided this study. The research that relates to each of the themes and secondary questions are presented along with the implications from this study. The limitations, revisiting the conceptual framework, and the need for further research are also included in this study.

Culture of Shared Leadership

The following findings address **Research Question 1**: *How is science leadership exhibited in a standards-based program?* The observations and the emails from the principals substantiated what the interview data revealed that there is shared leadership among the principals, teachers, and students. All three groups of stakeholders were instructional leaders and took ownership for learning. The principals supported and invested in the science teachers by putting forth their best effort to sustain science departments that focused on student achievement. This is similar to what Umphrey (2011) found in his study. As stated in the National Science Education Standards,

> Who provides such leadership is not as critical as ensuring that the responsibilities for support, maintenance, assessment, review, revision, and improvement of the programs are effectively carried out so that students have opportunities to learn and teachers have the opportunity to teach. (NRC, 1996, pp. 211–212)

Principals accomplished this task by embedding teacher leadership in the vision of the science department by expecting everyone in the department to be instructional leaders. Several studies have discussed teacher leaders as key figures in improving instruction (Lambert, 2003; Lieberman & Miller, 2004; Little, 2003; Murphy, 2002). Principals trusted and respected their teachers by allowing teachers to take the lead on hiring highly qualified staff. To promote teacher growth, the leaders created natural opportunities for teachers to lead instruction as part of the observation process. This is similar to the support of science education described by the Standards—leaders "model behaviors and are advocates for the science program" (NRC, 1996, p. 223). As instructional leaders, the principals monitored teaching and learning by visiting science classrooms daily, providing feedback, suggestions, concerns and accomplishments that spoke to the level of instructional expectations found in both schools. An example of feedback included: "I am seeing less teacher directed instruction and more independent, hands-on student led classrooms. This type of instruction is expected with the Common Core."

Every teacher was a leader of science knowledge and involved in employing other teachers who were well versed in science. This is similar to the findings that describe exemplary science teachers as teachers who have a vast amount of content knowledge (Alsop et al., 2005; Tobin & Fraser, 1990). With this expertise, teachers took the lead on observing, critiquing their peers and providing feedback on instructional practices. Teachers expected students to be fully engaged in scientific learning by allowing students to take the lead and share responsibilities for their own learning, individually and as members of groups because leadership can be vested in a variety of people, including students (NRC, 1996). Teachers did so by supporting students' ideas and questions and by encouraging students to pursue them. Teachers gave individual students active roles in the design and implementation of investigations, in the preparation and presentation of student work to their peers, and in student assessment of their work. This created one of the highest cultures of shared leadership that I have ever seen in schools.

Culture of Expectations for Learning, Culture of Varied Experiences, and Culture of Continuous Learning

The following findings address **Research Question 2**: *How are instructional practices, curriculum, and professional development aligned to science standards and supported in order to establish and achieve high expectations for students in science?*

The observations and documents substantiated what the interview data revealed--that these teachers planned lessons that were aligned to the National Science Education Standards. Their lessons came from standards-based curriculum and all of the teachers collaborated in planning and sharing of ideas. Teachers embraced the standards as the guidelines for what students need to know by displaying standards daily in order to ensure that students were aware of expectations for learning because “ content standards are a complete set of outcomes for all students” (NRC, 1996, 103). Teachers adapted the learning to something the students could do hands-on that produced data and artifacts from which they could make inferences, draw conclusions and develop reports. “What students learn is greatly influenced by how they are taught” (NRC, 1996, p. 33). Every teacher organized lessons for individual responsibilities and collaboration. Students worked together in groups to complete laboratory assignments and I found students to be more engaged in activities where they designed experiments that required self-discovery. Teachers established student-centered classrooms which resonates with the findings of Smith (2011) “reflecting students in the curriculum” (p. 3) and facilitated instruction when necessary to guide students towards scientific thinking by posing a problem or question about which the students could make predictions or hypotheses. “Students had minds-on experiences” (NRC, 1996, p. 2). All of the teachers served as facilitators by constantly circulating among the groups urging, guiding, probing and assisting with making connections. This allowed the groups opportunities to engage with each other in explaining, clarifying, and justifying what they had learned. This correlates with Wellington’s (2005) study on the involvement of students in “learning science,” “learning about science,” and “learning to do science” (p. 313). However, all teachers constantly reminded students of their individual responsibilities and group responsibilities as they advanced through each assignment.

The science curriculum was extended beyond the school day at both schools and according to the *National Science Education Standards*, “good science programs require access to the world beyond the classroom” (NRC, 1996, p. 219). In addition to the traditional tutoring, schools offered multiple field trip opportunities such as; Eco-Station and NASA competition (Washington, D.C.). They offered an array of clubs such as; Science Olympiad, Science Bowl, Scientific Committee, Environ-thon, Brain Bee, Physics Club, Biology Club, etc. which offered students opportunities to make investigations of the world beyond the classroom.

All teachers in this study were highly involved in professional development. “Practicing teachers, traditionally the targets for professional development have the opportunity to become sources of their growth as well as supporters of the growth of others,” (NRC, 1996, p. 58). In addition, some of the teachers held Master’s degrees and one had a Doctorate degree. All of the teachers belonged to professional organizations related to science. Several teachers had participated in national, state, as well as local science conferences. Examples of the types of experiences these teachers have engaged in are: university research, writing science assessment questions for the state department, and Advanced Placement workshops in science. They also shared with their peers by planning and together to create lesson plans, sharing ideas, and to support and guide instructional practices. According to the National Science Education Standards (NRC, 1996), “the conventional view of professional development for teachers needs to shift from technical training for specific skills to opportunities for intellectual professional growth,” (p. 58).

Culture of Feedback and Culture of Observations

The following findings address **Research Question 3**: *How does aligning assessments to science standards and evaluating standards-based science programs impact student learning?* Assessments were encouraged by the participants because “assessments define in measurable terms what teachers should teach and students should learn” (NRC, 1996, p. 75). Writing and questioning served as a means of self-assessing. Students were able to reflect on their own ideas and used rubrics to assess themselves and each other’s work. As stated in the *National Science Education Standards*,

> Involving students in the assessment process does not diminish the responsibilities of the teacher—it increases them. It requires teachers to help students develop skills in self-reflection by building a learning environment where students review each other’s work, offer suggestions, and challenge mistakes in investigative processes, or poorly supported conclusions. (NRC, 1996, p. 42)

Developing reports, designing experiments, problem-solving, and making presentations to the class served as performance assessments (e.g., tests, quizzes, lab reports, portfolios, essays, homework) and was transformed into a valuable feedback system that provided the teacher with information about students' level of understanding in all of the classes that I observed. Besides the traditional paper-pencil test, I did not observe many individual assessments.

Students were encouraged to evaluate teaching methods. "Through evaluations, students clarify ideas of what they are to learn" (NRC, 1996, p. 88). As representatives of good teaching practices, these teachers "modeled reflection and fostered a learning environment where students were offered suggestions and challenged mistakes" (p. 88). Students provided feedback on all assessments. Some examples included:

"Test reflected material taught."

"Labs were beneficial."

"Diagrams on test helped."

"Good variety of questions on test."

"Multiple choice on test too hard."

"Make test like homework."

"AP problems too confusing."

"Add AP questions to practice test."

Students also evaluated their study methods. Some examples included:

"Explaining to others."

"Doing Sign Off & Team Quiz for Understanding."

"Asked for extra help."

"Worked through questions myself/did homework."

"Make less careless errors."

“Did not review sign off etc.”

“Remember variables.”

“Study before the last day.”

In addition to the students benefitting from assessments, teachers viewed this process as opportunities to reflect on their craft. Some examples of questions that they asked themselves included: “What did I do to help the students? What could I have done better? This evaluation process created one of the most data rich environments that I could ever imagine to take place in a school. As noted in NRC (2012), “teachers should use assessments to plan for, revise and adapt instruction; to evaluate teaching and learning and to guide the pace and direction of instruction” (p. 320). This is consistent with the recommendations from Kali et al. (2008) providing feedback on how well expectations are being met.

Research Question 4

The following findings address **Research Question 4**: *Which standard is perceived by science educational leaders as most critical for an exemplary science program?* Professional development was most critical for exemplary science programs. Teachers were provided opportunities to study and engage in research on science teaching and learning. They also shared with colleagues what they had learned. Mr. Davis mentioned, “Most of our science teachers have on-going research backgrounds and they are willing to share this knowledge with everyone.” As noted in the *National Science Education Standards* (NRC, 1996), “Professional development for teachers of science requires integrating knowledge of science, learning, pedagogy, and students; it also requires applying that knowledge to science teaching” (NRC, 1996, p. 61).

Teachers created collaborative learning environments with each other. Within these environments, teachers created lesson plans that aligned curriculum, instruction, and assessments. These environments were also designed so that teachers could receive help, support, ideas, strategies, and solutions to their problems. As Ms. Walter stated, “We work well together by sharing ideas, not afraid to challenge each other, and we encourage one another to do our best.” Professional learning environments for students were also created. “Schools in which risk-taking is encouraged will provide learning communities for adults as well as for students” (NRC, 1996, p. 69). Students were involved in critiquing and assessing teaching and learning. They also took responsibility for their learning and the learning of others.

Some teachers were members of professional science teaching associations. As aligned to the *National Science Education Standards* (NRC, 1996), “those types of groups provide safe and rich learning environments in which teachers can share resources, ask and address hard questions, and continue to learn” (NRC, 1996, p. 70). As Mrs. Barbour stated, “The professional opportunities that we have with each other, the listservs, and workshops brings strength to our department.” Peer observation, coaching, and mentoring beginning teachers in either structured or unstructured settings also provided teachers safe havens to promote and enrich professional growth.

In addition to the professional science associations and organizations, principals participated in some of the professional development opportunities in order to increase their understanding of student learning in science and teachers roles and responsibilities. As aligned to the *National Science Education Standards* (NRC, 1996),

> Professional development programs therefore must involve administrators and other school staff. All must be committed to ensuring that prospective teachers, new teachers, and practicing teachers who wish to implement new ideas as part of their professional development are supported and integrated into the ongoing life of the school. (p. 71)

Study Implications

This study has strong implications for science programs who seek exemplary status. These science programs need relevant professional development opportunities for all teachers at all stages of their careers. This professional development must be linked to teachers' classroom practices and needs as well as closely tied to standards and district guidelines. These teachers need to be highly qualified to teach science. They need to be well versed in science content and they need to be enthusiastic about science teaching. Teachers should attend workshops sponsored by science organizations in order to stay updated on national curricular materials. They need to observe teachers who are in exemplary science programs and work closely with these teachers.

Schools and school systems need to provide funding in order for teachers who wish to further their learning beyond an undergraduate degree have opportunities to do so.

Teachers need appropriate tools to use to assess student learning. These assessment tools should also help teachers facilitate instruction in order to develop effective instructional practices. Teachers need to lecture less and provide more engaging, exploratory, hands-on activities where students are the workers and teachers are facilitators. Classrooms need to be structured so that students can share in making decisions and take ownership of their learning.

Exemplary science programs need the support from administration on all levels. It would be nearly impossible to have an exemplary science program without the instructional support of principals and district administration and the support of local businesses, colleges, universities, and community leaders. With this support, teachers need to extend the science curriculum beyond the world of the classroom. The best instruction that teachers need to offer students will not readily be available in textbooks and supplementary materials.

Standards provide a vision for teaching and learning, but the vision cannot be realized unless the standards permeate the education system and guide curriculum, instruction, teacher preparation, and professional development, and student assessment (NRC, 2012). These changes are needed in science education so that implementation of the standards can more readily occur if we expect our students to think like scientists.

Limitations and Directions for Future Research

There are two major limitations that should be taken into account when considering the results of this investigation. First, this case study was limited to two science programs, and this severely limits the transferability (Patton, 2002) of the results to the science practices of other schools and leadership practices of other principals. Although case study research is time intensive and provides a rich description of the phenomena being studied (Patton, 2002), the reader must be responsible for determining the extent to which the results of this case study are applicable to other science programs and other principals.

A second related limitation concerns the fact that the data that was collected and reported in this study does not include perspectives of students and other stakeholders regarding the status of exemplary science programs utilizing National Standards and leadership practices. Adding this information could have provided distinctive perspectives regarding the work of the teachers in these science programs as well as the school principals and could have added valuable insights regarding the particular behaviors the teachers and the principals engaged in that the students and other stakeholders perceived as critical influences on the impact of exemplary standards-based science programs.

Although this investigation provides a detailed description of how National Standards enacts science programs and leadership practices, further research is needed to present a more complete understanding of how exemplary science programs conceptualize and bridge the gap between research and practice. This research should include more cross-case analyses and individual cases to investigate possible recurring themes or patterns across settings (urban, suburban, rural, private) and school levels (elementary, middle, other high schools). For example, how do science programs and leadership practices in high-poverty schools conceptualize and bridge the gap between research and practice, and how does the work of these science educators differ from that of science educators in low-poverty schools?

Future research is needed to understand how educational programs for principals have been enacted to ensure that new principals understand the standards. What changes have occurred in administrators' preparation courses taken by these principals? What kinds of professional development programs have been offered to the administrators themselves so that their understanding, interpretation, and uses of the standards support their instructional decision making?

Finally, more research is needed to understand how educational programs for teachers have been enacted to ensure that new teachers understand the standards. What changes have occurred in the science courses taken by these teachers? What steps have been taken to ensure a more equitable distribution of exemplary science teachers so as to give all students access to learning opportunities consistent with the standards.

A Final Word—Revisiting the Conceptual Framework

The conceptual framework for this study utilized the existing theory and research on exemplary science teaching of *The National Science Education Standards* (NRC, 1996). This historical document that identify the characteristics of exemplary science teaching and science programs, along with my own experiential knowledge as an experienced high school science teacher, assistant principal, and NCDPI Science Instructional Coach, served as the conceptual framework and purpose for this study.

The conceptual framework worked well for this investigation. It allowed me to ask exemplary science teachers in these exemplary science programs what they think of the *National Science Education Standards* and leadership. While my own experience has provided an opportunity to understand the history and importance of the existing theory and research, it also helped me understand the teachers' perspective. Using this lens helped me identify with the participants, and it allowed me to ask meaningful questions and probe for deeper understanding.

Upon further reflection about this study an alternative conceptual framework for a similar future study, one theory for educational organizations proposed by Peterson and Deal (2002) and Fullan (2007) might be worth considering. This theory is the cultural theory. The cultural theory is based on everything that happens within a school and for this study, everything that happens within a science department. According to Peterson and Deal (2002), the definition of culture includes “deep patterns of values, beliefs, and traditions that have been formed over the course of the school’s history” (p. 4). Also according to Fullan (2007) school culture can be defined as the guiding beliefs and values evident in the way a school operates.

The culture found in these exemplary science departments impacted how these departments operated. Inspired by Michael Fullan’s (2007) book titled *Leading in a Culture of Change*, I make a case that change described in this book is more than leading effectively under chaotic circumstances. In his book, Fullan described the kind of leadership necessary to bring about systemic change in the organization. Fullan proposed how leaders foster leadership in others, thereby making themselves dispensable in the long run.

Science educators lead effectively while utilizing National Standards. In reflecting on this study, I will articulate some of the similarities I see between these instructional leaders and what is seen as “culture of change” and what was emphasized in my study as “culture of standards” in Table 19. An alternative visual representation of bridging the gap between research practice to develop a “culture” that allow science instructional leaders to implement exemplary standards-based science programs might be worth considering (refer to Figure 29).

Table 19

Similarities between Leading in Culture of Change and Leading in a Culture of Standards

Leading in a Culture of Change	Leading in a Culture of Standards
Collaborative Leadership: school leaders establish and maintain collaborative relationships with school staff.	**Culture of Shared Leadership**: widely shared sense of purpose and values that are consistently shared among all stakeholders which are set forth by the standards. In exemplary science programs, “Leadership should emerge from a shared vision of science education and from an understanding of the professional, social, and cultural norms of a school that is a community of learners” (NRC, 1996, 223). An effective leadership structure that includes teachers must be in place. “The leadership structure might take many forms, but it inevitably requires that teachers and administrators rethink traditional roles and responsibilities and take on new ones” (p. 223).
Unity of Purpose: teachers work toward a common mission for the school.	**Culture of Expectations for Learning**: a sense of personal responsibility for student learning; not blaming the student for not being successful. Students are provided clear instructions and an understanding of the standards. Teachers in exemplary science programs are familiar with a wide range of curricula. They have the ability to examine critically and select activities to use with their students to promote the understanding of science. “Curriculum developers indicated that the National Science Education Standards have the potential to stimulate the reform of science education and that they see curriculum developers as having a central role in the reform of science education” (NRC, 2000, p. 71).
Learning Partnership: teachers, parents, and students work together for the common good of the student.	**Culture of Varied Experiences**: sense of providing several learning options, or different paths to learning, which help students take in information and make sense of concepts and skills that are set forth by the standards. In exemplary standards based science programs, “Implementing standards-based reforms requires both that teachers be willing to change their instruction and that they have the capacity to do so” (NRC, 2000, p. 112). The literature also indicates that teachers who have been exposed to the NSES and standards-based professional development are more likely to feel well prepared to implement some of these strategies, such as taking students’ prior conceptions into account when planning and implementing science instruction (NRC, 2000). In exemplary standards based science programs, “Implementing standards-based reforms requires both that teachers be willing to change their instruction and that they have the capacity to do so” (NRC, 2000, p. 112). The literature also indicates that

Table 19

(Cont.)

Leading in a Culture of Change	Leading in a Culture of Standards
Learning Partnership (Cont.)	teachers who have been exposed to the NSES and standards-based professional development are more likely to feel well prepared to implement some of these strategies, such as taking students' prior conceptions into account when planning and implementing science instruction (NRC, 2000).
Professional Development Role: describes the degree to which teachers value continuous personal development and school-wide improvement.	**Culture of Continuous Learning**: a sense of real focus on professional development, staff reflection and sharing of professional practices set forth by the standards. In exemplary standards-based science programs, "Becoming an effective science teacher is a continuous process that stretches from pre-service experiences in undergraduate years to the end of a professional career" (NRC, 1996, p. 55). Teachers of science are professionals responsible for their own professional development and for the maintenance of the teaching profession. Courses and other activities include ongoing opportunities for teachers to reflect on the process and the outcomes of their learning. "Districts should use the professional development standards to provide teachers with opportunities to develop and enhance the needed capabilities for effective science teaching" (p. 219).
Collegial Support: describes the degree to which teachers work together effectively.	**Culture of Feedback**: a sense of focus to which teachers and students work together to engage students in ongoing assessments of their work and that of others and teachers ongoing assessments of exemplary teaching as prescribed in the standards. In reviewing the research and literature from the last decade on assessments influenced by, or consistent with, the National Science Education Standards will engage students in situations that require inquiry, the construction of explanations, the testing of these explanations, and the application of science questions to new content. It is critical for the assessment task or situation to elicit students' responses that make their thinking process visible (NRC, 2001b). Reporting results from assessments will incorporate ways for tracking students' progress over time, giving students appropriate feedback that emphasizes learning goals derived from the National Science Education Standards (NRC, 2000), and informing instruction. What teachers, administrators, and the public believe assessments are and believe how assessments should be used should be compatible with what is advanced by the National Science Education Standards.

Table 19

(Cont.)

Leading in a Culture of Change	**Leading in a Culture of Standards**
Teacher Collaboration: describes the degree to which teachers engage in constructive dialogue that furthers the educational vision of the school.	**Culture of Observations**: a sense of opportunities for individual and collegial examination and reflection on classroom instructional practices, for teachers to receive feedback about their teaching, and to understand, analyze, and apply that feedback to improve their practice as prescribed by standards. In exemplary standards-based science programs, “For schools to meet the Standards, student learning must be viewed as the primary purpose of schooling, and [observations of science programs] must support that purpose” (p. 233).

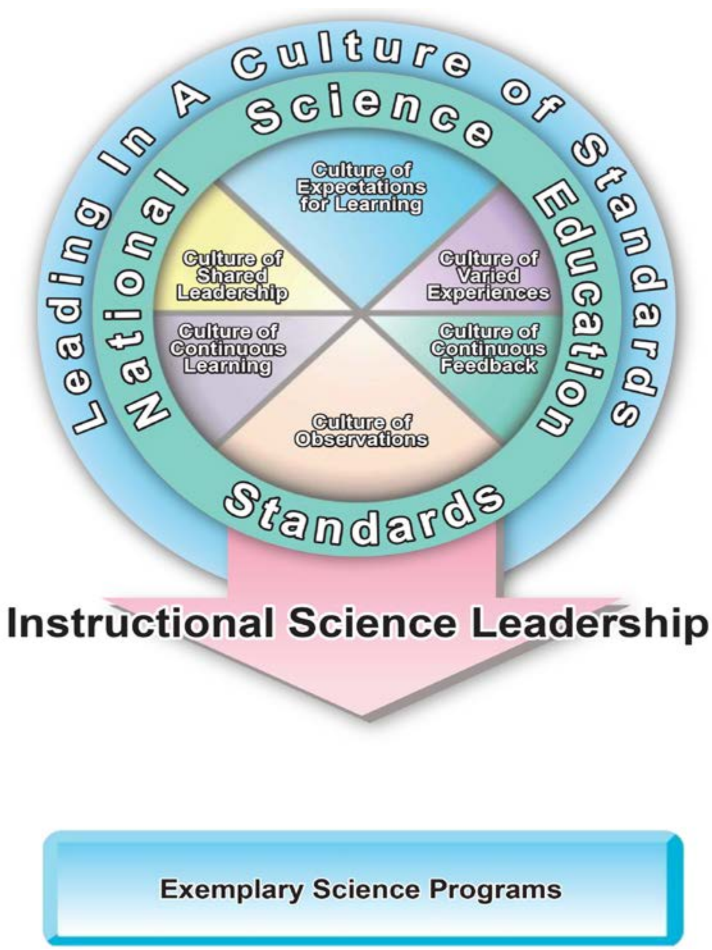

Figure 29. The National Science Education Standards Correlated with Leading in a Culture of Change (Fullan, 2007).

Exemplary standards-based science programs in schools do not occur by chance. It takes more than what traditionally has been understood as exemplary science programs and exemplary instructional leadership to achieve greater excellence. To be clear, science leadership and science programs in this study goes beyond what has been seen as exemplary science programs and science instructional leadership and raises the challenge to recast exemplary science programs and science instructional leadership as *Leading in a Culture of Standards*. Similar to Fullan's (2007) argument for "*Leading in a Culture of Change*," science leadership that is not focused on and successful at producing "leaders of leaders" and science programs that are not producing the capacity to seek, critically assess, and selectively incorporate new ideas and practices continuously, inside the science department as well as outside of it is indeed not exemplary.

The kind of science programs that needs to be defined and discussed as exemplary science programs in this study are programs that have pioneered and science programs that utilized National Standards to help chart the course into the future. By building on the best of current skills, the standards took science practices in this study beyond the constraints of present structures of schooling toward a shared vision of excellence. Exemplary standards-based science programs are indeed what science programs should be. The exemplary standards-based science programs and leadership practices described in this study gives vivid examples of what is possible, what is necessary, and what is described as *Leading—in a Culture of—Standards*.

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APPENDIX A

IRB FORM

THE UNIVERSITY *of* NORTH CAROLINA
GREENSBORO

OFFICE OF RESEARCH INTEGRITY
2718 Beverly Cooper Moore and Irene Mitchell Moore
Humanities and Research Administration Bldg.
PO Box 26170
Greensboro, NC 27402-6170
336.256.0253
Web site: www.uncg.edu/orc
Federalwide Assurance (FWA) #216

To: Wendy Carpenter
Ed Ldrship and Cultural Found

From: UNCG IRB

Approval Date: 9/23/2013
Expiration Date of Approval: 7/11/2016

RE: Notice of IRB Approval of Exempt modification
Submission Type: Modification
Expedited Category: Minor Change to Previously Reviewed Research
Study #: 13-0237
Study Title: A study of science leadership and science standards in exemplary standards-based science programs

This submission has continues to meet the requirements of an Exempt application/approval.
Submission Description:

The modifications consist of the letters from the participating school districts that are allowing me to conduct my rearch study in their school districts.

Investigator's Responsibilities

Stamped copies of consent forms and other recruitment materials will be scanned to you in a separate email. These consent forms must be used unless the IRB has given you approval to waive this requirement.

Please be aware that valid human subjects training for all members of research team need to be kept on file with the lead investigator. Please note that you will also need to remain in compliance with the university "Access To and Retention of Research Data" Policy which can be found at http://policy.uncg.edu/research_data/.

CC:
Carl Lashley, Ed Ldrship and Cultural Found

APPENDIX B

EMAIL RECRUITMENT

Email recruitment (follow-up email if I do not get enough participation)

My name is Wendy Carpenter and I am a current doctoral student at UNCG. I am writing to ask if you would be willing to be a part of a research study designed to help provide an understanding of science leadership and standards-based science programs. I am particularly interested in finding out how science leaders implement practices that are aligned to exemplary standards-based science programs. It is important for me to get multiple perspectives from several different sources within the school.

It is my goal to recruit at least 9 science teachers and the curriculum facilitator to share their experience with me during two 60 to 90 minute interviews. The principal and/or assistant principal will share information during two 60 to 90 minute interviews with me to answer additional questions. The second interviews will be set aside for member checking. The researcher will also observe your science practices for 30 minutes. Your identity will remain confidential throughout this whole process as well as the school and school district. I will assign fictitious names to protect your identity. If you are interested in sharing your story about the impact that science leaders and science standards have on the effectiveness of science programs please respond back to my email. I would like to thank you in advance for taking time out of your busy schedule to be a part of this study.

Participation in this study is strictly voluntary; and you may withdraw at any time without penalty. There are no financial rewards. I plan to conduct interviews, do observations, and collect other documents about your school during the Summer and Fall semester. If you are interested in being a part of this study or want additional information, please contact me at ___________.

Sincerely,

Wendy Carpenter

APPENDIX C

CONSENT TO ACT AS A HUMAN PARTICIPANT

UNIVERSITY OF NORTH CAROLINA AT GREENSBORO

CONSENT TO ACT AS A HUMAN PARTICIPANT

Project Title: A study of Science Leadership and Science Standards in exemplary Standards-Based Science Programs

Project Director: Wendy Carpenter

Participant's Name:

What is the study about?
This is a research project. Your participation is voluntary. The purpose of this case study will be to assist in the understanding of how science leaders enact leadership in science programs and how these practices are interpret in exemplary standards-based science programs.

Why are you asking me?
You are being asked to participate in this study because you are a science leader in your school.

What will you ask me to do if I agree to be in the study?
You will be asked to participate in 2 interviews that will last between 60 to 90 minutes each. The second interview is for member checking. You will agree to allow the researcher to observe your science practices for 30 minutes. All interviews and observations will take place at a time and location most suited to your needs and the researcher will keep notes confidential.

There are minimal risks associated with this study. The activities that you will engage in during this study will pose minimal risk. Participants are subject to questions and debriefing that may be stressful or uncomfortable although attempts are made to avoid this. If for any reason this occurs, you can stop participating in this study immediately and you will be provided with information of someone that may assist you should issues in the study arise.

Is there any audio/video recording?
Interviews will be recorded using digital recorders. The recordings will be used to construct written transcripts of interviews.

Because your voice will be potentially identifiable by anyone who hears the tape, your confidentiality for things you say on the tape cannot be guaranteed although the researcher will try to limit access to the tape as described below.

What are the dangers to me?
The Institutional Review Board at the University of North Carolina at Greensboro has determined that participation in this study poses minimal risk to participants.

You should not be harmed by this study. However, if you feel that you are harmed in any way, please contact Wendy Carpenter at ______ or via email _______.
If you have any concerns about your rights, how you are being treated, concerns or complaints about this project or benefits or risks associated with being in this study please contact the Office of Research Integrity at UNCG toll-free at (855)-251-2351.

Are there any benefits to society as a result of me taking part in this research?
If we are to prepare our students for careers in science, findings may offer opportunities for leaders to improve their effectiveness as science leaders by making a difference in science education.

Are there any benefits to *me* for taking part in this research study?
There are no direct benefits to participants in this study.

Will I get paid for being in the study? Will it cost me anything?
There are no costs to you or payments made for participating in this study.

How will you keep my information confidential?
All information obtained in this study is strictly confidential unless disclosure is required by law.

The researcher will inform the subjects that their responses will remain anonymous and fictitious names will be assigned to facilitate analysis of the data. Information will be combined with information from other people taking part in the study. Subjects will not be identified in any public or presented material. No one except the researcher will know the information given was provided by the subjects. All transcripts and interview notes will be kept for 5 years and then destroyed. Digital recordings will be destroyed after they have been transcribed. All transcripts, digital recordings and interview notes will be kept in an undisclosed location off campus and will be secured until destroyed. Data will have been de-identified when the tapes are destroyed.

For Internet Research, absolute confidentiality of data provided through the Internet cannot be guaranteed due to the limited protections of Internet access. Please be sure to close your browser when finished so no one will be able to see what you have been doing.

What if I want to leave the study?
You have the right to refuse to participate or to withdraw at any time, without penalty. If you do withdraw, it will not affect you in any way. If you choose to withdraw, you may request that any of your data which has been collected be destroyed unless it is in a de-identifiable state.

What about new information/changes in the study?
If significant new information relating to the study becomes available which may relate to your willingness to continue to participate, this information will be provided to you.

Voluntary Consent by Participant:
By signing this consent form you are agreeing that you read, or it has been read to you, and you fully understand the contents of this document and are openly willing consent to take part in this study. All of your questions concerning this study have been answered. By signing this form, you are agreeing that you are 18 years of age or older and are agreeing to participate, or have the individual specified above as a participant participate, in this study described to you by _Wendy Carpenter____.

Signature: ________________________ Date: ______________

APPENDIX D

SCIENCE TEACHERS INTERVIEW PROTOCOL

Science Teachers Interview Questions

Exemplary Standards-Based Science Programs	Interviewing Questions	Research Questions	Case Study Methods		
			Interviews (I)	Observation (O)	Documents (D)
Curriculum	How is the science curriculum developed?	How is the curriculum aligned to science standards and supported in order to establish and achieve high expectations for students in science?			
	Which standards-based documents were consulted?				
	How is the science curriculum used and implemented in your school?				
	What is the format of the science curriculum (pacing guide)?				

	How does the science curriculum relate to other science classes in your school and to other schools in your district? How completely does the science curriculum address the standards of the North Carolina Essential Standards? Do you have adequate materials and supplies to teach science? Is there anything that you need to be better able to teach science as aligned to the standards? Is the science curriculum extended beyond the classroom? If so, how?	
Instruction	What factors do you consider when deciding on your teaching strategies for any particular day?	How are instructional practices aligned to science standards and supported in order to establish and achieve high expectations for students in science?

	When developing a new science unit, how would you go about planning that unit? What steps would you go through? What factors do you consider when selecting resources for your class? What adaptations are made to meet the needs of your students? What is a typical day of teaching science like for you? What are your preferred strategies for teaching science? Why are they preferred? What are the benefits and limitations?	
Assessment	What factors are considered when designing or selecting an assessment for your science classes? What types of assessment strategies do you use	How does aligning assessments to science standards impact student learning?

	in science? How do you use data from formative and summative assessments to inform science instruction? How do you provide feedback to students? How often?	
Evaluation	How is standards-based science programs evaluated? What are the expectations of a standards-based science program? How do science instructional leaders support science evaluation with the focus on improving performance and student achievement in science?	How does evaluating standards-based science programs impact student learning?

Professional Development	Have you had professional development related to the science curriculum? If so when, and how was it related to science standards? What kind of professional learning do you engage in to stay current and to improve your effectiveness in science classrooms? What professional organizations are you involved in? How are you involved? How does the principal support professional development and learning communities? What do you see as the major strengths of the science program? What areas are most in need of improvement?	How does aligning professional development to science standards impact student learning?
Leadership	Who was involved in the curriculum development process in science? How does your	How is science leadership exhibited in a standards-based program?

	principal create and utilize processes to distribute leadership and decision-making in science? How is collaboration supported in science?

Background Information

1. How many total years have you been employed as a science teacher?
2. How many total years have you been employed in the school/district in which you are currently working?
3. Which science course (s) are you currently teaching?
4. Is there anything else you would like to add?

Student Learning

APPENDIX E

PRINCIPAL/CURRICULUM FACILITATOR INTERVIEW PROTOCOL

Principal/Curriculum Facilitator Interview Questions

Exemplary Standards-Based Science Programs	Interview Questions	Research Questions	Case Study Methods Interviews (I)	 Observations (O)	 Documents (D)
Curriculum	How is the science curriculum developed?	How is the curriculum aligned to science standards and supported in order to establish and achieve high expectations for students in science?			
	Which standards-based documents were consulted?				
	How is the science curriculum used and implemented in your school?				
	What is the format of the science curriculum (pacing guide)?				

	How does the science curriculum relate to other science classes in your school and to other schools in your district? How completely does the science curriculum address the standards of the North Carolina Essential Standards? How do you ensure that teachers have adequate materials and supplies to teach science? Is there anything that you think they may need to be better able to teach science as aligned to the standards? Is the science curriculum extended beyond the classroom? If so, how?	
Instruction	What factors do you consider when observing science teaching	How are instructional practices aligned to science

	strategies? What resources are selected to enhance learning in science classes? Describe a typical day of science teaching. What adaptations are made to meet the needs of students in science? Is the science curriculum extended beyond the classroom? If so, how?	standards and supported in order to establish and achieve high expectations for students in science?
Assessment	How is standards-based science programs evaluated? What are the expectations of a standards-based science program? How do science instructional	How does aligning assessments to science standards impact student learning?

	leaders support science evaluation with the focus on improving performance and student achievement in science?	
Evaluation	How is standards-based science programs evaluated? What are the expectations of a standards-based science program? How do science instructional leaders support science evaluation with the focus on improving performance and student achievement in science?	How does evaluating standards-based science programs impact student learning?
Professional Development	Have you had professional development related to the science curriculum? If so when, and how	How does aligning professional development to science standards impact student learning?

	was it related to science standards? What kind of professional learning do you engage in to stay current and to improve your effectiveness in science classrooms? How does the principal support professional development and learning communities? What do you see as the major strengths of the science program? What areas are most in need of improvement?	
Leadership	Who was involved in the curriculum development process in science? How does the principal create and utilize processes to	How is science leadership exhibited in a standards-based program?

distribute leadership and decision-making in science?

How is collaboration supported in science?

Student Learning

Background Information

1. How many total years have you been employed as a principal/curriculum facilitator?
2. How many total years have you been employed in the school/district in which you are currently working?
3. Which class (s) did you teach when you were a teacher?
4. Is there anything else you would like to add?

APPENDIX F

OBSERVATION PROTOCOL

Background Information

Name of Teacher/Principal: ______________________ Date of Observation: ________________
Location of Observation: ________________________ Grade Level: _______________________
Start Time: __________________ End Time: _________________________

Curriculum

How is the curriculum aligned to science standards and supported in order to establish and achieve high expectations for students in science?

Instruction

How are instructional practices aligned to science standards and supported in order to establish and achieve high expectations for students in science?

Assessment

How does aligning assessments to science standards impact student learning?

Evaluation ***How does evaluating standards-based science programs impact student learning?***	
Professional Development ***How does aligning professional development to science standards impact student learning?***	
Leadership ***How is science leadership exhibited in a standards-based program?***	

APPENDIX G

DOCUMENT PROTOCOL

Research Questions	Documents	Connection to Standards/Practices
Curriculum How is the curriculum aligned to science standards and supported in order to establish and achieve high expectations for students in science?		
Instruction How are instructional practices aligned to science standards and supported in order to establish and achieve high expectations for students in science?		
Assessment How does aligning assessments to science standards impact student learning?		
Evaluation How does evaluating standards-based science programs impact student learning?		
Professional Development How does aligning professional development to science standards impact student learning?		
Leadership How is science leadership exhibited in a standards-based program?		