EXAMINING BARRIERS TO IMPLEMENTATION OF INQUIRY-BASED SCIENCE: A MIXED METHODS STUDY OF 6TH- 8TH GRADE SCIENCE TEACHERS IN ONE RURAL DISTRICT

A Dissertation
by
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Submitted to the Graduate School
at Appalachian State University
in partial fulfillment of the requirements for the degree of
DOCTOR OF EDUCATION

May 2014
Educational Leadership Doctoral Program
Reich College of Education

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Abstract

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This study was carried out in response to the call of the National Research Council (2012) and the American Association of the Advancement of Science (2001) for sweeping change across K-12 education in order for the United States to become a nation of scientifically literate citizens. As the National Research Council calls for change, Atar (2011) posits that many barriers stand in the way of changes in curriculum, instruction, teacher preparation, professional development, and student assessment.

This inquiry focused on a rural school district in North Carolina and its efforts to implement a new inquiry-based science curriculum entitled Science Education for Public Understanding Program (SEPUP) for all 6th- 8th graders. Using teachers' perspectives, data were collected regarding fidelity of implementation, barriers to the process were examined, and possible ways to overcome those barriers were explored. Using a mixed methods approach, anonymous online surveys and six face-to-face interviews were used to collect data (Creswell, 2012).

This study on implementing a new inquiry-based curriculum found that: (1) fidelity of implementation must be defined before programs can be evaluated, (2) time, testing, accountability policies, and lack of support are the main barriers to implementation and (3) the most effective tool in overcoming the barriers is teacher collaboration.

The implications of the findings were used to improve my knowledge of successful program implementation and to inform future efforts in educational reform. The analysis revealed a tension between best practices, such as inquiry-based methods, that are encouraged in educational policies and the standardized assessments that are being used to assess teacher effectiveness. This finding is critical for grant funders, educational agencies, and public officials who mandate curriculum changes. Locally, understanding barriers to implementation with a focus on teacher collaboration will promote stronger fidelity of implementation.

Acknowledgements

I want to acknowledge the Office of Student Research (OSR) at Appalachian State University and Dr. Allen C. Utter, Director of OSR, for funding this research. These funds allowed the interviews to be conducted professionally and transcribed efficiently.

I would also like to acknowledge the funding received from the Golden Leaf Foundation Grant and Senior Vice President, Mark Sorrells. This funding purchased the SEPUP Science Curriculum for the district. This grant introduced me to program evaluation and continues to encourage me to learn more about how best to conduct evaluation.

Dr. Barbara Nagle, SEPUP Director, of the Lawrence Hall of Science graciously allowed me copyright permission to use part of the SEPUP overview documents. She also provided me with documented research on the SEPUP curriculum. Her valued expertise was integral to producing quality data.

Dedications

This project was completed with the help and encouragement of my dissertation committee: Dr. Krista Terry (Chair), Dr. Les Bolt, and Dr. Jeni Corn. These mentors walked me through the journey with patience and guidance. Malinda Faber of The Friday Institute guided me through the data and provided great assistance. In addition to the committee, a classmate, Justin Mitchell, supported me. After riding up the mountain every week together for 2 ½ years, we also kept in touch to encourage one another as we both struggled through this process.

The backbone of my support team was my family and my faith, which carried me through! My husband Ted Moore sacrificed a great deal over the last three years. In a marriage in which we had always done everything together, it was difficult to spend so much time separated as I worked on this project and he worked on others. During the frustrating times, he listened and encouraged me as I promised him there was a light somewhere at the end of the tunnel. My daughter Rachel graduated from Western Carolina University and moved out to start her first teaching job during this process. She also sacrificed my full attention during these exciting and stressful times in her life. My son John, soon to graduate and start his first year at the University of North Carolina at Charlotte, has sacrificed my attention as well during these exciting years of high school and college preparations. My family has been my support. I deeply thank them and plan to make it up to them very soon.

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CHAPTER 1

Introduction

Three years ago, I wrote and was awarded a $250,000 grant from the Golden Leaf Foundation of North Carolina. The majority of the funds were used to purchase a new inquiry-based middle school science curriculum and related training materials. The curriculum provided all necessary equipment, supplies, grading rubrics, integrated lessons, and literacy strategies. The program is known as Science Education for Public Understanding Program (SEPUP). SEPUP is an issues-based curriculum, with each unit built upon a real-life problem or issue. The students are introduced to the problem, carry out several activities and strategies to study the science behind the problem, and then complete each unit with a project or product suggesting a solution to the problem that had been introduced.

Working as the K-12 Science Curriculum Specialist in my district, I have found no other curriculum that could be compared to this one, which provided pages of research on its positive impact on student learning. Unfortunately, as I visited classrooms during the second year of implementation, it became evident that many of the teachers were not implementing the new curriculum. I was perplexed as to why some teachers did not adopt the curriculum. As a former classroom teacher for over 20 years, I could not imagine why a teacher would not use this packaged program with all the materials and a rich curriculum that employed inquiry-based methods. After working with the teachers for over two years on program implementation, I decided to examine the barriers to full implementation of this new program because it was important within the context of the improvement of science instruction. I soon found that the issue of improving science instruction was being addressed on a larger national scale.

The Committee on Prospering in the Global Economy of the 21st Century (Augustine, 2007) states that the United States is in danger of losing its competitive edge in science and technology that it has had for the last 80 years. The committee argues that science and technology are important for economic progress in the United States. An expansion of the national concerns to global concerns is shared by the American Association of the Advancement of Science (2001), who's mission includes improving science, innovation, and engineering across the world to benefit everyone. It is stressed within the *Atlas of Science Literacy* that all elementary and secondary school children need to become better educated in science, mathematics, and technology .The development of Project 2061 by the American Association for the Advancement of Science questions the United States' ability to act decisively enough to prepare young children, especially the minority population, for a world shaped by science and technology (Rutherford & Ahlgren, 1994). The American Association for the Advancement of Science (2001) and the National Research Council (2012) claim that in order for the United States to become a nation of scientifically literate citizens, sweeping changes across K-12 education need to be made.

In the United States, the National Research Council (2012) has engaged in the development of the new *K-12 Framework for Science Education*. The National Research Council (2012) recognizes that changes in science education are needed to develop scientifically literate citizens and cannot be made without permeating the education system through changes in curriculum, instruction, teacher preparation, professional development, and student assessment. While the National Research Council (2012) does not directly reference inquiry-based instruction as a method to reach its goals, it is one method by which their overarching goal can be reached. Inquiry-based instruction is encouraged and recommended by the National Science Teachers Association when it states that "scientific inquiry is a powerful way of understanding science content. Students learn how to ask questions and use evidence to answer them" (National Science Teachers Association, 2004, para. 3). Inquiry-based instruction may be applied to help the National Research Council reach its goal that all high school graduates will have sufficient knowledge of science and engineering, in order to hold public discussions concerning science-related issues, be careful consumers, and be sufficiently prepared to enter the career of their choice.

In order to make constructive changes in education, each program, curriculum, and educational practice needs to be evaluated to determine its worth. Yet, governments and school systems continue to seek a "silver bullet" for meeting the educational needs of children without taking the time required for thorough evaluations. They have jumped from new program to new program without full evaluation of effectiveness. Often educational organizations attempt to evaluate programs but rarely are afforded the time and resources to do so before another program takes its place. A true evaluation of progress cannot occur if all evaluated teachers, schools, or systems are not using the researched-based program or curriculum as it is designed to be used, which can be referred to as fidelity. Fidelity of implementation is the measure of whether a program or method is used as it was intended or designed to be used (Harn, Parisi, & Stoolmiller, 2013).

As the National Research Council calls for changes in curriculum, instruction, teacher preparation, professional development, and student assessment, many barriers stand in the way of these changes (Atar, 2011). Identification of these barriers is critical. This study will identify and examine the barriers that impeded the full implementation of the SEPUP curriculum.

This chapter will introduce the reader to educational evaluation, the research problem and approach to the research, the context of the new curriculum and its implementation, the research questions and methodology, and finally the significance of understanding barriers to curriculum implementation.

Educational Evaluation

Educational evaluation in the 21st century is, in the eyes of policy makers, synonymous with accountability for teachers' effectiveness as measured by student test scores. King and Rohmer-Hirt (2011) maintain that evaluation of educational programs will remain secondary in priority to the administration of standardized testing. This statement is based on the established national policies that affect the educational system and the international comparisons of student achievement between different countries. Nevo (2009) maintains that the schools have long been controlled by means of external evaluation to support the demand for public accountability. The demand for public accountability is supported by a string of policies over the years, which became No Child Left Behind (NCLB) in 2002 (King & Rohmer-Hirt, 2011). While the accountability models change and continue to increase the emphasis on high stakes testing, Ryan (as cited in King & Rohmer-Hirt, 2011) posits that educational evaluation and accountability are relegated to audits while the goals of improving learning and teaching are ignored (King & Rohmer-Hirt, 2011).

Educational evaluation has become a means of re-establishing public trust in the government, enhancing efficiency, and applying evidence in anchoring policy and decision making (Ryan & Cousins, 2009). These foci have also developed out of comparative education, which can be traced back to 1817 and Mark-Antoine Jullien who established a European institute for comparative education research using a standardized questionnaire throughout Europe (von Kopp, 2010). von Kopp (2010) claims that "comparative education in theory, research, and practice is about 'border crossing" (p. 17). International assessments are used to compare national educational systems without regard to national contexts, and the results are driving policy and decision making (Ryan & Cousins, 2009). As nations compare international standardized tests, these assessment results are becoming the focus of educational evaluation initiatives. If an educational program appears to produce higher international standardized test scores, then that program would be rated high for its effectiveness on student learning.

Rather than focusing on the global and national understanding of educational evaluation widely synonymous with standardized testing, this research focused on one aspect of program evaluation. The primary focus of this study was to understand the implementation of an inquiry-based science program and identify the barriers to implementing it.

Educational evaluation has a broader spectrum of purpose that includes four genres (Ryan & Feller, 2009). One genre uses scientific evaluation with emphasis on evidence-based policy and programming to identify which programs work and which do not. Other genres are performance measuring and monitoring for capacity building (Lundgren, 2009), learning and discovery oriented evaluation, and political or values-oriented evaluation. Zohrabi (2011) reiterates that without evaluation of educational programs, the level at which student needs are met cannot be established. He contends that program evaluation is an ongoing process that starts at the beginning of implementation and continues even after the program has been completed in order to establish improvements to a particular course of study or program. Zohrabi (2011) summarizes this type of educational evaluation thusly: “[u]nderstanding, disentangling, disaggregating, and hypothesizing about educational similarities and differences as well as judging the quality and effectiveness of these educational experiences are all essential for improved educational programs and policies” (p. 553). Educational program evaluation plays an important role in improving education and making the changes prescribed by the National Research Council.

Overview of Implementation

This is a study of a single North Carolina school system’s attempt to improve science instruction. This study seeks to identify the barriers to implementation of a new curriculum in order to move toward the calls for improvement of science education by the National Research Council and American Association for the Advancement of Science. Using grant funds, the rural district that was examined purchased an inquiry-based curriculum developed by the Science Education for Public Understanding Program (SEPUP) for all 6^{th}- 8^{th} grade science teachers.

The SEPUP curriculum included three full-year curricula: one in the life sciences, one in the physical sciences, and one in the earth sciences. Each unit was assigned to the grade level that aligned with the essential standards in the standard course of study. Each unit is issues-based, meaning it provides an introductory lesson/activity that sets the stage for a real-world application. A series of lessons introduces the science content and uses literacy strategies and hands-on activities to work toward a solution to the issue introduced in the initial lesson. The final lesson requires students to write a letter to an organization, create a product, or suggest a solution to the problem.

An example of one of the units can be found in Appendix A. The biotechnology unit begins with asking students to explore problems related to performing certain tasks when a dominant arm is injured. They invent solutions to the problems they encountered and then read about strategies used to address problems of certain disabilities. After several more lessons on designing artificial heart valves and exploring bone construction using chicken wings, the final project is to design and construct a mechanical arm that can move a mass a specified distance. This last assignment brings the unit full circle and back to the original introductory activity of the injured arm.

The Friday Institute of North Carolina State University, which is an organization working to bring teachers, students, researchers, policy makers, and community members together to foster educational collaboration, has been contracted to evaluate grants for the funder, the Golden Leaf Foundation of North Carolina (The Friday Institute, 2014). Both the Friday Institute and the Golden Leaf Foundation have played key roles in guiding the evaluation of this grant.

The Golden Leaf Foundation awarded grants to middle schools and districts to provide research-based curriculum and professional development to increase student interest in Science, Technology, Engineering and Mathematics (STEM) careers. The implementation of the SEPUP curriculum is one of the projects awarded to my district.

My entire career has been spent working in this district. For 23 years, I worked in the middle school classrooms in several of the feeder districts. Because of several moves, I was privileged to work with different staff, in different schools and community cultures. I was able to build bridges with those teachers, administrators, and communities over the years. As the K-12 Science Curriculum Specialist for five years, I have worked closely with all the science teachers, particularly the middle school teachers, since middle school education is my predominate area of expertise. These work experiences provided me with an avenue for open communication with the science teachers involved in this study which focused on teachers' points-of-view shared in interviews and surveys concerning barriers of implementation of the new program.

Problem Statement and Approach to Research

The general problem addressed in this study was to identify and understand why new teaching methods are not readily adopted. The barriers to implementation and possible methods for overcoming barriers were investigated in an average-sized rural public school district. This county school system was composed of five feeder districts, with each district having one high school, one middle school and three to four elementary schools.

As states and school systems work to provide inquiry-based science curriculum to schools, prudence calls for selection of the most effective resources. Unless the selected curriculum is delivered by the educators in the classroom with fidelity (the extent of how the program is being used as it is intended), the quality of the resource cannot be determined with confidence. The student outcomes cannot be determined until fidelity of implementation can be defined and determined. Therefore, until teachers are using the SEPUP curriculum in the way it was designed to be used, the student impact cannot effectively be measured or analyzed.

The intent of this sequential explanatory mixed-methods study was to examine barriers to implementation of the new SEPUP curriculum. In the study, data were collected through an anonymous online survey, teacher highlighted SEPUP lessons taught in each unit, and six teacher interviews. The highlighted lessons taught by each teacher helped define fidelity of implementation of the program and helped establish a list of teachers to interview and final interview questions.

Following the analysis of common themes in the online survey section that was open-ended, the barriers were more deeply explored by conducting interviews with six key participants in six different schools in the same district. The reason for the sequential data collection was to use the survey data, which all participants were asked to complete anonymously, to improve the questions for the interviews. While the survey allowed all teachers a voice in the collection of the data, the interviews offered more detailed responses and more insight into the issues of the barriers that may not have been obvious in the survey.

Context of SEPUP Curriculum

To better understand the implementation of the SEPUP program in this district, it is important to have a clear understanding of the training and support offered to the teachers. This information was drawn from the reports to the Golden Leaf Foundation that I completed at the district level every six months.

In the spring of 2011 the SEPUP curricula were purchased and all 7^{th} and 8^{th} grade teachers attended full-day trainings with a SEPUP trainer. In the fall of 2011 these same teachers worked together to create pacing guides and evaluate the unit and lesson alignment with the standard course of study. That same fall the 6^{th} grade teachers were trained and developed their pacing guides, rotation schedules for the kits, and alignment with the standard course of study. Since the 6^{th} grades are housed in the elementary schools, the 6^{th} grade science teachers received their grade level assignment in the summer and therefore could not attend training until the fall. The 6^{th} grade science teachers also have to share and rotate the kits within a feeder district. Since the initial trainings in 2011, the teachers have met two more times to work through issues and discuss how best to implement certain activities in the curriculum. I have been responsible for organizing these events the last three years and stocking refurbishment materials as needed.

In addition to the training, when materials were difficult to locate, broken, lost or consumed, teachers contacted me throughout the year for assistance. When educators had difficulty accessing online student books, videos, and interactive learning tools, I worked with the company's representative until the situation was rectified. The company was persuaded to send out copies of the student books to every teacher to project onto the large movie screen when the internet resources were not working.

Also included in the August 2012 grant interim report, I reported that out of 22 informal walk through observations completed in various schools within the district, 19 of the teachers were using SEPUP lesson plans and materials. On the other hand, in the report filed during February of 2013, I found through observations and interviews at two of the middle schools that 7th grade teachers were using SEPUP for 90% of their instruction while most of the 8th grade teachers were only using SEPUP for 10% of their instruction. These significant data points led to the research questions. I began wondering what variables were causing such a discrepancy. What was happening to cause this change over time and why were the changes related to grade levels taught?

Research Questions

The following two primary questions were investigated through the use of more specific supporting questions. Each supporting question is related to one of the barriers discovered in the literature. When implementing a new curriculum, what are the barriers that exist, as expressed by teachers? How do teachers' believe these barriers may be overcome? The sub-questions are:

- To what extent is the new science program being implemented to fidelity?
- What role does time play in the implementation of the new program?
- What roles do testing and accountability play in implementation of the new program?
- What roles do administrators play in the implementation of the new program?
- What roles do teachers' beliefs and teaching philosophies play in the implementation of the new program?

Methodology

To be able to more accurately determine the barriers that exist for implementation of the SEPUP inquiry-based science program, mixed methods were used. The quantitative data were collected from all participants (6^{th}- 8^{th} grade science teachers) in the district who had access to the curriculum, and the qualitative data, collected from only six participants, allowed a more descriptive illustration of the implementation and the barriers to implementation in context. A sequential approach was used in order for the data previously collected to inform the collection of the new data through interviews.

The interviews were conducted in the fall of 2013. The survey, administered in the spring of 2013, was provided by the Friday Institute of NC State University in collaboration with the Golden Leaf Foundation of North Carolina. The second set of preexisting data (highlighted lessons) was each teacher's submission of SEPUP lessons used throughout the year. This preexisting data was analyzed to determine and define fidelity of implementation for the study and also to inform the interview questions that followed. Both data sets were analyzed during the same semester. The two data sets were compared to create a clear narrative of the implementation.

The data sources are located in Table 1. The teacher highlighted lessons were provided by all 6th- 8th grade science teachers. All 6th- 8th grade science teachers were invited to participate in the Friday Institute survey but only 26 responded (55%). Using a stratified sample, six participants were selected across 6th- 8th grade science teachers, and interviews were conducted.

Table 1

Data Sources

		FI Survey Data		
	Teachers Highlight Lessons Taught	Open-Ended Responses	Likert Scale Responses	Interviews
Research Questions: To what extent is the new science program being implemented with fidelity?	●			
What are the major barriers to a new inquiry-based science program being implemented and what are possible ways to overcome these barriers?		●		●
What role does time play in the implementation of the new program?		●		●
What roles do testing and accountability play in implementation of the new program?		●		●
What roles do administrators play in implementation of the new program?		●		●
What roles do teachers' beliefs and teaching philosophies play in the implementation of the new program?		●	●	●

The purpose of using both quantitative and qualitative data was to create a more complete understanding of the phenomena by including context into the research. Maxwell (2005) agrees with Greene (2007) in claiming that ignoring the context of quantitative data can damage credibility and that the researcher's critical subjectivity is a critical part of the process of analysis. Using quantitative data alone, the researcher would be ignoring the differences in school cultures, administrator influences, student needs and ability levels, and teachers' abilities, experiences, and pressures. The interviews added elaboration and context of why certain curricular decisions were made. This information cannot easily be found in quantitative data when used in isolation.

Significance of Issue

As the National Research Council (2012) states, the United States has too few workers with strong backgrounds in the science and engineering fields. Therefore, the National Research Council strongly upholds that change is needed in the approach public education is taking for instruction because children deserve access to quality curriculum and materials to enhance their learning. Selecting appropriate and effective curriculum to enhance learning is challenging. When considering the high costs of curriculum development and purchasing, curriculum developers, grant funders, state and local school boards, administrators, and those charged with making curriculum decisions need to understand the realities of implementing programs given the continued threat of reduction of funding to public schools and the exploding costs of curriculum and curriculum development.

Greene (2007) broadens the significance of this study as she claims that program evaluation and fidelity of implementation is necessary for: (a) assisting policy makers in decision making, (b) improving the program being evaluated, (c) developing a deeper understanding of the program and its practices, and (d) leading to greater justice and equity in the program under study. Program evaluation is invaluable to all stake-holders in order to assure continued improvement. The intent of my research was to uncover possible barriers to an inquiry-based science program implementation developed by SEPUP in order to ultimately outline possible ways to overcome those barriers. Some barriers may be intrinsic, such as a teacher's self-confidence or self-efficacy, while some may be extrinsically affected because they were wrapped in organizational or systemic factors such as time, policies of accountability, and support structures for implementation.

A predominant intrinsic barrier is a teacher's belief that she may not be able to implement the methodology. Marshall, Horton, Igo, and Switzer (2009) posit a gap in the research around teacher self-efficacy believing more studies need to investigate how self-efficacy can be increased. If teachers are not confident of their abilities to implement new strategies or curricula, they may not attempt the implementation. They explain that teacher self-efficacy needs to be determined so that interventions can be put into place to boost self-efficacy and lead to changes in instructional practices. A teacher's belief that she can implement a new program or method effectively, and that it ultimately aids in student learning needs to be encouraged. If teachers believe they can effectively use an inquiry-based curriculum and it meets students' needs, they would more readily adopt its use.

If a teacher is not confident with the subject matter, she will most likely avoid inquiry-based methods and migrate to more traditional instruction, focusing on text and questions. Inquiry-based methods and experiential learning activities require a teacher to have a strong understanding of content to know how to guide and lead students' questions. A study that examines barriers to implementation of science inquiry curriculum can result in a change of practice for schools, districts, or states when implementing new programs. This type of study can also assist educational leaders in designing their implementation plans and addressing the stated concerns of increasing teacher self-efficacy, and teachers' understanding of inquiry-based instruction. The study can also add to the existing literature concerning issues of implementation of educational programs and educational policies.

CHAPTER II

Review of Literature

This literature review examines the barriers that may exist when implementing new curricula with new methods. The review will include: (a) constructivism and a brief history of inquiry science, (b) a focus on the paradigm shift to inquiry-based instruction, and (c) the barriers to that paradigm shift, particularly in science instruction.

Constructivism and the History of Inquiry Science

Inquiry-based science instruction is built on the theory of constructivism, which posits that students discover and create their own knowledge through their experiences. The philosopher John Dewey (1938), a proponent of constructivism and its ideals, proposed that there exists a "fundamental unity in the idea that there is an intimate and necessary relation between the process of actual experience and education" (p. 7). For learning to occur, not just simple memorization, one needs to experience a phenomenon to truly understand it. Dewey (1961) states that activity should not be an end in itself, but that it should lead to a change in thought by reacting with the activity and comparing the encounter with prior experiences when referring to the constructivist theory. Similarly, Mead (1964) proposes that:

> An experience is always what it is because of a transaction taking place between an individual and what, at the time constitutes his environment. The environment, in other words is whatever conditions interact with the personal needs, desires and purposes and capacities to create the experience which is had. (pp. 422-423)

Mead (1964) implies that experiences do not occur in isolation but are carried out in context. The environment may consist of the physical space, objects, other individuals in the space and personal preferences of the learner. All the factors play a part in interpretation of the event. Bredo (2000) describes classical constructivism as beginning with an activity and viewing conscious thought or awareness as emerging within conflicted activity. This conflict in the activity and awareness of it helps to reorganize thoughts and helps the action proceed. He concludes that all varied forms of constructivism have commonalities, such as knowledge is made not found. Also the subject and matter are intertwined and evolving together, insinuating that objects are humanly made and have some relationship to us and our activity (Bredo, 2000).

Because other individuals are part of the environment, Vygotsky adds to these ideas stating that learning is constructed through social interaction (Bredo, 2000). As individuals share their personal experiences and interpretations of events, they build understanding together to make meaning. Vygotsky (1993) continues to relate the child's learning to present and future experiences. These experiences need to be appropriate to the developmental needs of the child.

These philosophical ideas have helped to develop strategies and methods for the classroom. Working through problems and being allowed to make errors, individuals can create their own connections of cause and effect and will remember them because they experienced them first hand, rather than being told and then forgetting. A person can then start making connections between their new experiences and prior knowledge they bring with them to form new knowledge to be able to solve new problems. Bredo (2000) synthesizes the constructivist theories of Vygotsky, Dewey, and Mead by stating that they give priority to doing rather than knowing. He synthesized two implications of constructivism; students need to have an active role in learning, and they need to be allowed to redefine or discover new meaning for the objects in which they interact. In inquiry-based science, students are allowed an active role in their own learning when they are engaged in the manipulation of materials, data, peer interactions, and recording their thoughts and ideas. When the theory of constructivism is applied to learning, Haney, Lumpe, and Czerniak (2003) describe five components of constructivist teaching as: scientific uncertainty, student negotiation, shared control, critical voice, and personal relevance. Researchers have concluded that students must be given opportunities to engage in activities and reflect on those activities rather than sitting passively in the classroom, in order to become scientifically literate. These approaches have come to be identified as inquiry-based instruction (Jadrich & Bruxvoort, 2011). Yet, Richardson (2003) claims the translation of constructivist theory of learning to constructivist practice is difficult. He describes the characteristics of these practices as:

- Focus on student backgrounds and beliefs that relate to the subject of study,
- Collaboration of students to discuss and create shaped understandings,
- Introduction of formal knowledge through direct instruction, reference to text or web,
- Provision of opportunities to challenge, determine, or change beliefs through interaction with tasks and materials, and
- Metacognition to develop students' understandings of their learning process

These characteristics focus on developing students' awareness of how they learn through development of a classroom climate that uses activities and methods focused on developing students' understanding of content (Richardson, 2003). These teaching methods of inquiry-based science instruction are being encouraged throughout United States schools today by national organizations. According to the National Science Teachers Association's position statement (2004):

> Scientific inquiry is a powerful way of understanding science content. Students learn how to ask questions and use evidence to answer them. In the process of learning the strategies of scientific inquiry, students learn to conduct an investigation and collect evidence from a variety of sources, develop an explanation from the data, and communicate and defend their conclusions.
>
> The National Science Teachers Association (NSTA) recommends that all K–16 teachers embrace scientific inquiry and is committed to helping educators make inquiry the centerpiece of the science classroom. The use of scientific inquiry will help ensure that students develop a deep understanding of science and scientific inquiry. (para. 3-4)

The National Science Teachers Association is proposing that students be challenged to think like scientists. In order for students to analyze evidence, propose new explanations, recognize flaws in research or an experiment, students have to be thinking at the higher levels of Bloom's taxonomy such as evaluate and create, which can be accomplished by working with classmates using argumentation and discussion (Jadrich & Bruxvoort, 2011; Marzano & Kendall, 2007).

Inquiry-based science methods offer many challenges to teachers, such as: how to measure the quality of inquiry implementation in the classrooms, how teachers can use strategies such as discussions and student collaboration to encourage more effective inquiry-based learning; how to get teachers to think of content and inquiry not as a dichotomy but as integrated; and how to help teachers learn to manage the effective inquiry-based classroom (Jadrich & Bruxvoort, 2011).

Hassard (2000) recognizes the inquiry-based characteristics are related to what 8th grade students stated they wanted in a classroom: less textbook and more hands-on experiments, more learning in the outdoor setting and experiments, use of review games and guides, fun long-term projects, allowance to work in groups, and time to discuss and debate topics. Hassard (2000) notes that the students' preference to collaborate, work on projects, experiment, and debate issues form a parallel with the National Science Teachers Association's position statement of inquiry-based methods. In *8 Essentials of Inquiry-based Science, K-8,* Hammerman (2006) posits the following:

> Inquiry-based science is a natural approach for providing a variety of choices for how students will learn the concepts and the relationships between concepts they are investigating…and…teachers are encouraged to be creative in providing a variety of ways and a variety of contexts to enhance student learning. (p.111)

Hammerman (2006) also explains that inquiry-based instruction includes best practices such as developing student responsibility for learning, high student engagement, using formative assessment, and encouraging cooperative and collaborative learning with a focus on understanding. Coupled with a diverse use of classroom strategies is the sundry use of assessments such as observation checklists, interviews and dialogues, notebooks or learning logs, teacher-made tests, products and projects, performance tasks, portfolios, and standardized tests (Hammerman, 2006).

Michaels, Shouse, and Schweingruber (2008) insist that a child's capacity for scientific understanding must be reconsidered. Rather than using the deficit model of what young children are not able to do or ready to do, they claim that young children are bringing more life experiences to the classrooms. Inquiry-based instruction allows students to integrate those experiences into the learning process. This research illustrates how children have a more sophisticated way of observing the natural world than previously believed (Michaels et al., 2008). They are learning a great deal through observation and dialogue before they ever enter formal education. Inquiry-based instruction used in formal education with students of all backgrounds show evidence of sophisticated thinking (Michaels et al., 2008). Young students bring experiential understandings of the natural world to school with them, such as their understanding of gravity by observation, and cause and effect. These ideas are developed in conversations with family members, media, and visits to parks, museums, and summer camps, and even through rearing of a goldfish. In the classroom, students are able to discuss their ideas and explanations of their experiences. Educators can build upon what children already know by listening to them process their thinking and taking their ideas seriously (Michaels et al., 2008).

More recently Jadrich and Bruxvoort (2011) proposed a new expanded definition of inquiry science. They move beyond the inclusion of student developed questions, hands-on activities, process skills, and the application of the scientific method to the "creation, testing, and refinement of scientific models" (p. 9), which is the primary goal of scientists. These models, such as creating labeled drawings of magnetic fields around a magnet, would be tested with other students, discussed, and debated with peers. As researchers are extending the definition of inquiry-based education a method based on the theory of constructivism, it creates a difficult paradigm shift for educators using traditional methods in classrooms with emphases on using textbooks and lectures.

Inquiry Paradigm Shift

In 1996, the National Research Center published findings on the effectiveness of inquiry-based learning, in science programs; however, nine years after the publication, the research findings suggest most teachers are not implementing the reform (Johnson, 2006). In Turkey, Feyzioğlu (2012) also carried out research to identify which teachers were implementing constructivist teaching and traditional teaching.

Constructivist teaching is characterized by first-hand student experiences, solving problems and peer discussion (Vygotsky, 1993). Traditional teaching is characterized by the teachers acting as the giver of knowledge. When using traditional methods, the teacher is responsible for transmission of knowledge through lecture, followed by demonstration of the experiment. The teacher often uses repetition and writing, and is the authority and controller in the classroom (Feyzioğlu, 2012).

Inquiry-based teaching/learning is one example of a constructivist approach. One case in point is when a new science and technology program had been implemented since 2005 throughout Turkey (Feyzioğlu, 2012). The program had been heavily influenced by constructivism in its development. This curriculum change was a result of the research Turkey's educational leaders conducted on the educational practices in the countries that continued to show evidence of higher math and science skills in international testing. The countries investigated were applying constructivist theories to curricula. Several years later, through observations and interviews of eighteen teachers, Feyzioğlu (2012) found that even though many of the teachers expressed beliefs in hands-on, engaging practices, they often reverted to traditional teaching styles when encountering difficulties, finding those strategies more manageable. The return to traditional teaching methods was exemplified by the use of texts and text-based activities and teacher demonstrations prior to student's replication of activities. The teachers categorized as traditional teachers expressed concern in allowing students to discuss misconceptions for fear that they can disrupt class and lead to student behavioral problems.

This exemplifies how teachers' beliefs appear to drive methodological practices in the everyday classroom. When analyzing the teachers categorized as constructivist teachers, the teachers described themselves as guides to help students discover the concepts while students were mentally active and engaged with the materials (Feyzioğlu, 2012). They also were more accepting of conversation during class activities. Feyzioğlu (2012) also correlated teacher classification (traditional to constructivist) to years of teaching experience. If the teachers were categorized as constructivist, they had less than ten years of teaching experience. Many of the teachers explained that they had been trained in constructivist methods as pre-service teachers. No constructivist teachers had more than ten years of experience, but the more experienced teachers were categorized by the use of traditional methods. Based on Feyzioğlu's findings, changing teachers' instructional paradigms from traditional to constructivist methods or inquiry-based methods is not easily accomplished.

Glickman, Gordon, and Ross-Gordon (2010) claim that for paradigmatic change to occur, teachers must develop their "own repertoire, relative to their own physical and mental characteristics and their students" (p. 93). Teachers are individuals that will have to determine how best to incorporate changes in curricular or methodological delivery into their personal styles of teaching.

If teachers cannot or will not change their methods, how will they implement new inquiry-based curriculum that is contrary to their teaching methods and philosophies? It is necessary to know if teachers are using the new curriculum or method before program evaluation can occur. Implementation of the program must be defined clearly prior to the evaluation.

Conceptual Framework: Definition of Fidelity of Implementation

Before taking a closer look at the barriers to implementation of new programs, the definition of fidelity of implementation needs to be determined. Unless it is evident that the teacher is using the program the way it was designed to be used, effectiveness cannot be measured. Programs may range from selected activities to be used at the discretion of the educator or mandates teacher scripts that are to be read verbatim for each activity every time it is used. Therefore, the fidelity of implementation needs to be defined before valid research can be carried out for an evaluation of a particular program.

Practitioners define fidelity of implementation from a variety of perspectives. While the specific components of fidelity of implementation are not agreed upon Harn et al. (2013) and Azano et al. (2011) suggest the following components, but state that it is not necessary to use all five during research: adherence, exposure, program differentiation, quality of delivery, and participation responsiveness. Therefore, Harn et al. (2013) elected to evaluate their third-grade language arts program based on adherence and quality of delivery. Webster-Stratton, Reinke, Herman, and Newcomer (2011) only use the following three components in determining the level of fidelity of implementation leading to program sustainability and improved outcomes: clearly identified components with built-in adaptations, differentiating professional development experiences, and contextualizing and embedding coaching. Breitenstein et al. (2010) suggests six components of fidelity of implementation: practitioner selection, pre-service and in-service training, on-going coaching and supervision, assessment of implementation, administrative support and system interventions. These components are offered as a feedback loop system whereby the system interventions would then lead to improved practitioner selection.

Harn et al. (2013) suggest that when defining fidelity of implementation, the components can be classified into two categories. The first category, surface fidelity, is the predetermined important elements of intervention such as time allocations and intervention completion of expected lessons. These may be measured by self-reporting or direct observation. The second category, process, includes the quality of delivery and student-teacher interactions. Both are important, but the first category of data is significantly less laborious to collect and analyze, while the process of the quality of delivery of the intervention takes a great deal more effort. Prior to researching implementation of any program, the fidelity of implementation components must be identified and defined by the researcher.

Although a definition was stated above, neither fidelity of implementation and nor its practical meaning is clear. A binary is created between the understanding of fidelity of implementation as fixed or flexible. For instance, while researching a certain drug counseling program, Breitenstein et al. (2010) found that practitioners report a positive relationship exists between adherence and outcomes, but others found perfect adherence less effective. He theorized that good intentions with a moderate level of adherence were more productive, due to expertise and the individualized treatment of each client. The practitioners may be implementing the core components of a protocol, but doing so with poor to moderate skill resulted in diminished outcomes. Breitenstein et al. (2010) suggests that while interventions may be effective in clinical trials where the environment is highly regulated, they may not be as effective in real life contexts where defining fidelity of implementation is subject to so many more variables, such as quality of delivery.

Harn et al. (2013) agree and state that a program's implementation may be related to practitioners independently modifying the practice to better suit the local context yet some consider this a contradiction to fidelity. Still others claim that the practitioner's innovations may lead researchers to understanding, improved practices and more effective interventions. Harn et al. (2013) note that core ingredients of a program should not be fundamentally altered if the program is to be effectively evaluated with confidence. Therefore, the core ingredients need to be established prior to evaluation. Finally, they claim "Practitioners will adapt practices to match contextual variables (e.g., student skill level, student demographics, and schedules) and deliver responsive instructional practices" (p. 188). Harn et al. (2013) provide an example of a program consisting of 60 lessons in early literacy that had been identified as an Evidence-Based Practice (EBP), yet no research has been done to see if only 40 of the lessons were carried out. Perhaps the student achievement may even diminish at 60 lessons rather than 40. Perhaps with 40 lessons the student would have achieved the same results or after 50 lessons, the student started regressing. If the student already understood the first 10 lessons, should the teacher skip the first 10 lessons, or move through them faster than prescribed? Thresholds have not been researched; therefore, an argument exists for flexibility of fidelity of implementation.

Finally, Webster-Stratton et al. (2011) state that educators must, "balance between adaptation and implementation with high fidelity" (p. 190) and that "fidelity data is inherently multi-leveled in structure, with teachers nested in schools and students nested within teachers" (p. 190). For each program evaluation, fidelity of implementation must be established as flexible or inflexible and then defined before the process can begin. Once fidelity of implementation is determined and defined, the possible barriers to its implementation can be analyzed.

Barriers to Implementing a New Program

In order to measure change and implementation, a line has to be drawn to determine fidelity of implementation. When this is defined and measured, barriers to change can be investigated. Schimmel and Muntslag (2009) identify factors in organizational learning theories that are necessary for organizational change. They posit that three pre-conditions must exist for an effective organizational learning process to occur. First, individuals must be allowed to learn, then individuals must be able to learn, and finally individuals must be willing to learn the new strategy, method, or program. These three conditions are necessary for stakeholders of an organization to learn new processes and strategies for change. This section will identify many of the barriers to the implementation of new programs and will also address the issue of fidelity of implementation.

Extrinsic. Extrinsic barriers are identified in the literature as time, testing/accountability, and support. Most of these variables stand outside the teachers' control and affect them from outside themselves, such as state and local policies, schedules, or principals.

Time. When considering time as a barrier, it is difficult to separate this variable from the others already stated. Time is intertwined with mandated curricula that are assessed with annual high stakes testing and administrative support. The curriculum is so large at each grade level and the accountability, as measured by standardized testing, is so great; teachers must rely on traditional methods of teaching in order to cover more of the objectives in the time frame provided. It is difficult to carve out the time to teach many, much less all, of the required concepts in an inquiry-based manner. It takes more time to allow students to create experiments, discuss and then analyze data. Therefore, traditional methods allow for the "coverage" of the material in a timely manner (Argon, Berends, Ellis, & Gonzalez, 2010; Marshall et al., 2009). Marshall asserts there is a need to "combat the dichotomization of content and inquiry where teachers feel one is achieved at the expense of another" (p. 594). With a limited amount of time daily and during the academic year, the prioritization of time on content versus inquiry are perceived to be in opposition. Because of the tight schedules during the school day, most of the activities involved with inquiry-based methods take a great deal of time to develop and/or prepare for the next day. This preparation requires more of the teacher's personal time, and he or she still must attend to the required duties of all teachers, leading to more stress (Johnson, 2006).

Additional time is needed for teacher collaboration when moving to inquiry-based instruction, or any change in methodology (Glickman et al., 2010; Johnson, 2006; Oliva, 2009). Glickman et al. (2010) indicate that time is not usually allocated for teachers to discuss curriculum and instruction, yet it may be necessary for methodological changes urged by the National Research Council (2012) to take place. Educators need time to collaborate on what is working and not working and share suggestions with each other. This can be done in faculty meetings, in-service workshops, peer-observations, conferences, and other informal discussions (Glickman et al., 2010). Time to teach, time to plan and prepare, and time to collaborate are all variables that may affect the paradigmatic shift within a single classroom, the school, or system.

Another variable is time for sustained professional development. Research shows that the duration of any professional development and training of less than 80 hours will not result in sustained change in the classroom (Hill, Maucione, & Hood, 2007; Johnson, 2006). This time is needed to change teachers' philosophies regarding teaching and sustainable collaboration. This is exemplified in some grants such as the Math/Science Partnership grants that are federally funded requiring a minimum of 80 hours of professional development to apply for funding (North Carolina Public Schools, 2003).

Johnson (2006) suggests that training for implementation of new curriculum or methodology is necessary because teachers with a strong content and pedagogical background tend to be more successful in changing methodologies. If teachers do not have a strong understanding of content knowledge, inquiry-based methods are difficult to implement. Marshall et al. (2009) concur by expressing that the inquiry process is complex requiring much training for teachers to fully engage students.

Time allocated to teach required objectives, prepare for inquiry instruction (including lab preparations), and adequate training are challenges that must be addressed for changing instructional methods. The mandated curricula and accountability policies also affect the time to teach.

***Standardized Curriculum and Accountability*.** With a focus on science curriculum, most states include science inquiry as part of their standards at every grade level, leading many teachers to teach an introduction to science inquiry at the beginning of the year, before delving into the science content. Most textbooks even separate a science inquiry chapter from the content chapters (Quigley, Marshall, Deaton, Cook, & Padilla, 2011); however, the integration of the method and the content is not occurring, especially with the concern that there is too much content to cover in one year with no time to develop conceptual understanding (Azano et al., 2011; Ratcliffe, 2004).

The mandated curricula paired with high-stakes testing and accountability become highly restrictive, ignoring considerations for student differences. In order for teachers to teach using inquiry-based methods, they must carry out contrasting goals of promoting student independent thinking and still training them to think the same way, focusing on fact-based relationships that will be found on mandated tests (Wallace, 2012). Johnson (2006) agrees that mandated science assessment is in direct conflict with inquiry-based science and constructivist approaches. As teachers are under great pressure by administrators, community, and government to show high proficiency scores, they focus on test preparation, which is most readily taught using traditional methods. They teach the content directly in order to address the many of the objectives that are to be included on the final assessments. Inquiry-based methods transform the teacher's role to one who guides the students in the discovery of concepts. As students explore the concepts, each may reach understanding differently. The different understandings may not align with the single correct answers on the standardized multiple-choice tests.

Wallace (2012) claims that over the past 15 years, the science state standards in the United States have posed barriers to teaching and learning in school, especially when coupled with high-stakes testing and accountability. She shares personal experiences where teachers of students with poorer test scores were strongly encouraged to adopt teaching methods of those teachers achieving higher test scores. These same teachers were also warned they would be under closer scrutiny by the administration. This business model of efficiency has removed the trust of teachers as professionals to meet the individual needs of students. This loss of trust was translated into the movement of accountability of teachers and schools.

The influence of standardized testing is noted much earlier in educational research. Ornstein & Hunkins (2004) shares an eight-year study (1932-40) of the Progressive Education Association and found "most high school teachers and principals were reluctant to implement progressive changes because the curriculum was (and still is) test driven and dominated by college admission" (p. 90). In response to these findings, he found that students in 30 of those progressive programs did just as well or better than the control group using traditional methods of instruction on cognitive, social, and psychological evaluations. Although the assessment of progressive changes yielded positive results, most high school teachers chose not to implement the changes. Robert Sternberg (as cited in Ornstein & Hunkins, 2004) a proponent of critical thinking, is concerned with the findings that schools are still not choosing to implement changes, stating that schools are not preparing students to solve problems in real-life that involve social, economic, ethical and psychological implications entangled by relationships, stress, and crisis. Multiple choice tests and "right answers" are not adequately preparing students for the real world (Ornstein & Hunkins, 2004). This early study and the study conducted in Turkey (Feyzioğlu, 2012), provide evidence that the schools are still not meeting the sweeping changes urged by the National Research Council (2012) to improve science education.

Not only are curriculum standards and accountability barriers to the implementation of science inquiry-based methods, but Johnson (2006) addresses the "elephant in the room" in that science teachers need to be supported to do science inquiry rather than using science instructional time for sharpening reading skills for language arts and math state assessments.

This refers to the grade levels having state mandated tests in language arts and math, while science may not be tested.

Support. The support barriers to program or methodological changes can be identified as inadequate funding, lack of administrative support, and system or school policies. Agron et al. (2010) posit that funding was the number one barrier to implementation of a new health and wellness program. It was prescribed, but not fully funded as are many of the federal and state educational mandates. However, even if funding is adequate, other support barriers exist. Many researchers (Bond, Drake, McHugo, Rapp, & Whitley, 2009; Chin-Chung & Ching-Sing, 2012; Johnson, 2012) express concern, stating that administrators should not only support the change with supplies and resources, but also by providing time for collaboration surrounding the reform and overall institutional support. Educators need time to process the changes together to make continued modifications to fit the workings of particular contexts.

Although administration plays an active role in change in schools, innovations cannot be driven by top-down approaches because all participants must be involved for real change to take place within a school (Berge & Clark, 2005). In contrast, Marshall et al. (2009) state that teachers perceive the sense of administrative support as crucial. Yet, the most influential elements in federal and state educational policy may be standardization of curriculum and accountability that are beyond administrative and teacher control (Berge & Clark, 2005).

Intrinsic. Intrinsic barriers, which can be defined as those barriers that are internal to an individual, are identified as teacher beliefs and self-efficacy. These deal with the affective realm of the teachers' personal feelings, beliefs, and confidence.

Teacher Beliefs. The need for many hours of professional training, support and collaboration can all be connected to what teachers believe is most effective in the classroom. Empirical studies have confirmed the assertion that employees' attitudinal and behavioral reactions to change play a major role in the success of implementation (Shin, Taylor, & Seo, 2012). Second only to funding, Chin-Chung and Ching-Sing (2012) state that intrinsic teacher beliefs and willingness to change is paramount to change in methodologies or programming. Employees generally see change as intrusive and disruptive in their routines and may increase the work expected of them, and some scholars even suggest that the internal negative emotions may cause them to become change adverse. This causes them to be reluctant to enact the program/procedure, seeing that it may increase the work load expected of them (Shin et al., 2012). Teachers are no different. Johnson (2006) admits that although sustained professional development is necessary to really change attitudes and beliefs of teachers, even the best professional development will not address all the existing beliefs teachers have. Permanent transformation requires a form of learning that modifies attitudes and cognition towards current practices (Schimmel & Muntslag, 2009). It is necessary to provide time for people to contribute to change and understand that change will not be immediate. Forcing a teacher into immediate modifications that may be in conflict with their teaching style is counter-productive (Glickman et al., 2010; Oliva, 2009).

Addis et al. (2013), while working with college biology professors, found they were reluctant to accept student-centered learning. The professors had been educated through lecture; they excelled in their lecture courses, and were at the top of their classes. Therefore, since they were at the top of their classes and learned best with this method, the rest of their classmates may have needed alternative methods to learn, but their personal experiences suggested lecture was the best means of teaching and learning.

Haney et al. (2003) claim that teacher beliefs impact the classroom and are crucial to systemic change. These beliefs or convictions of teaching and learning

- tend to be self-perpetuated;
- are prioritized according to connections with other beliefs;
- are difficult to change the earlier they are formed;
- influence perception;
- altered during adulthood are rare; and
- strongly effect behavior.

It is important to consider difficulties in changing adult beliefs since many beliefs about classrooms are formed as early as preschool or kindergarten experiences (Haney et al., 2003). Therefore, if teachers have held traditionalist views of learning and the classroom, moving them toward constructivist views will take a great deal of energy and time, and in some cases the change may never occur.

If classroom beliefs are not strongly developed during the early years of school experiences, pre-service learning experiences may establish the traditional belief system. Irez and Han (2011) found that most pre-service programs and practice experiences were founded in traditional methods, rather than constructivist and inquiry-based ideologies. Even so, during observations of high school biology teachers, Irez and Han noted that the more experienced teachers had the most difficulty with the new curriculum and offered the most resistance. Change was slow and arduous, but some changed with substantial support from colleagues and researchers. Irez and Han’s (2011) goal was not to create a pessimistic view of systemic change but to better understand and develop the psychological structure involved in educational changes.

Many teachers and stakeholders, such as students, parents, and community members, also have beliefs not only about teaching methods, but hold strong beliefs and expectations for disadvantaged students, which also inform the teacher's selection of methods. Many teachers tend to hold less rigorous standards for disadvantaged students (Torff, 2011). Torff reported on a series of studies that found teachers working in minority schools supported a less rigorous curriculum with fewer critical thinking activities. This reflected what Torff referred to as a "culture folk belief." It is the belief that disadvantaged students were not ready to handle critical thinking activities because the teacher would have posed a challenge that would be too frustrating. He also found that pre-service teachers, as well as in-service teachers, remained steadfast to their beliefs no matter how many experiences they had, how long they taught or how much in-service training they had. Therefore, if students were perceived as being unable to participate in critical thinking activities, they would always be taught in traditional methods and not provided opportunities to think critically in class.

The deficit view described by Torff (2011), is supported by Azano et al.'s (2011) research of 3rd grade gifted classrooms. The researchers found that when the teachers' expectations were low, even in a gifted classroom, so was the achievement. Since teachers held a deficit-oriented framework for their students, the teachers did not even carry out the programs to fidelity and, therefore, the students' achievement scores were not as high as those in classrooms where higher expectations and deployment of the program to fidelity were practiced.

The notion of teacher expectancy theory (Azano et al., 2011) highlights the struggle of fidelity of implementation and the effects of teacher expectations on student achievement. They note that teachers' expectations of students' learning capabilities are biased and are based on perception rather that actual capabilities. These teachers hold deficit orientations for students. When teachers hold lower expectations for students, fidelity of implementation is not followed because of a belief that the students cannot learn using a specific program, which teachers believe will lead to frustration for the child.

Self-Efficacy**.** The concept of self-efficacy grows out of the social cognitive theory, which explains how people develop and maintain certain behaviors. This can be classified into two dimensions (Bandura, 1977). The first is personal self-efficacy which measures one's beliefs in one's ability to perform a certain task, or more specifically described by Bandura (1997) as "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (p. 3). Outcome expectancy, often related to self-efficacy, measures one's beliefs that the task will produce a specified result. Lakshmanan, Heath, Perlmutter, and Elder (2011) posit that teacher efficacy, self-efficacy, and sense of efficacy can be used interchangeably. Self-efficacy and outcome expectancy are different, however, while appearing at first glance to be the same. Bandura (1977) believes that personal self-efficacy plays an important role in desired outcomes in that self-efficacy precedes outcome expectancy, if outcome expectancy is ever developed. An individual must first believe that he or she has the ability to perform a certain task prior to accepting the idea that the task may result in a desired outcome. Pajares (2002) states that self-efficacy is influenced by behavior, environmental events, and personal factors such as cognitive and biological events. These are reciprocally interacting so that if one or more of these factors are influenced, self-efficacy may be increased. Bandura (1997) claims that self-efficacy can be changed when provided appropriate environments because self-efficacy is malleable. They also imply the importance of increasing self-efficacy because it is correlated to skills needed to attain certain goals such as persistence in the face of difficulties and motivation to reach desired goals (Bandura, 1997; Pajares, 2002). Although teachers may have increased self-efficacy, they still may not have increased outcome expectancy.

Lakshmanan et al. (2011) and Powell-Moman and Brown-Schild (2011) outline the relationship in this way: if professional development leads to higher levels of teacher self-efficacy, higher levels of self-efficacy may in turn, translate into desired teacher behaviors that eventually lead to improvement in student achievement. This study aimed to reveal how self-efficacy may have influenced implementation of an inquiry-based curriculum that had revealed evidence of increased student achievement (Wilson, Sloan, Roberts, & Henke, 1995). Research of teachers' perceptions may reveal how a program is implemented, which may impact self-efficacy or vice-versa, fidelity of implementation, and finally student achievement. In an effort to place student achievement on the fast track, Woodbury and Gess-Newsome (2002) coined the phrase "change without difference." Emphasis was placed on teacher practices without accounting for teachers' beliefs and self-efficacy concerning the new practices. They insist the most profound influence in changing teacher practices and behaviors is teachers' abilities to learn.

In recent years, Southerland, Sowell, and Enderle (2011) indicate that literature suggests that teacher beliefs, although remarkably durable, can be changed through support and persistence. These efforts to improve self-efficacy are summarized in four major strategies according to Bandura (1993): (1) mastery experience when teachers achieve success of a task, (2) vicarious experience when an individual observes someone modeling a specific skill or behavior, (3) social or verbal persuasion by receiving social encouragement or verbal praise, and (4) physical or emotional states affecting the individual at the time of performing the task. He emphasizes that mastery experiences have the most influence in teacher self-efficacy.

In a study of integration of Web 2.0 tools into the classroom, Pan and Franklin (2011) use self-efficacy as the primary predictor of technology integration. They state that studies show that self-efficacy is a reliable predictor of behavioral change in technology integration. While they found self-efficacy to be the primary predictor of change, professional development and school administrator support were variables that promoted change. It is noted that professional development enhanced teachers' self-efficacy related to integration of technology into the classroom (Pan & Franklin, 2011).

In an evaluation of teacher efficacy and outcome expectancy across 14 grants in North Carolina, the Friday Institute of North Carolina State University data reveal that the dichotomy between self-efficacy and outcome expectancy continues to exist (Faber et al., 2013). The data reveal that when students achieve results higher than expected, the teacher was the influence; yet contradicting data shows that when students' achievements were lower than expected, teacher influence was not perceived as a factor. On the same survey, teachers indicated a high level of self-efficacy (Faber et al., 2013). Based on perception surveys with over 500 science, math, and technology teachers involved in STEM professional development and implementation programs, there continues to be a chasm between teacher self-efficacy and expected student outcomes. The data show that even while teachers express confidence in their abilities to teach science well, they are not as convinced that the student outcomes will be affected. Therefore, the challenge is to alter teachers' perceptions and beliefs of self-efficacy enough to affect their outcome expectancy. They need to understand and believe that their instruction has an effect on student learning, rather than focusing on a deficit model of the student.

Does high or low self-efficacy affect the perceived need to change teacher practices? Southerland et al. (2011) explore the concept of discontentment. They posit that teachers need to see a cause to change behavior through discontentment with their teaching practices or the outcomes. If they do not perceive a need for a change in behavior, teachers will not consider the new practice, but if they have discontentment and perhaps a low self-efficacy, they will focus their energies on learning new content, methods, and behaviors. Therefore, having an inflated sense of self-efficacy will prevent change in teacher behavior.

An inflated sense of self-efficacy is noted to cause resistance to change by Sunal et al. (2010). They state that dissatisfaction may increase willingness to change. The faculty members needed to see that their usual methods were not achieving desired results and that a new method would alter those results in a positive manner. Sunal et al. (2010) found that teachers required collaborative, systematic, and long-term professional development that provided plausible pedagogical ideas and collaborative experiences. This suggests that self-efficacy should not be oversimplified to be useful, but that when creating professional development experiences, teachers' self-efficacy and outcome expectancies need to be carefully considered (Southerland et al., 2011).

Chapter Summary

The history of inquiry-based science instruction, originating in the 1930s with John Dewey, continues to be touted today as an effective method of science instruction by the

National Science Teachers' Association (2004) as noted in their position statement. As the education arena has become filled with many issues, barriers continue to impede the utilization of inquiry-based methods in typical science classrooms. These barriers include: time, testing/accountability, professional development, support, teacher beliefs, and self-efficacy which hinder fidelity of implementation for each program. Fidelity of implementation must be achieved in order for educational programs to be evaluated for effectiveness. With a limited amount of time to educate students, quality curriculum and materials can aid students in learning.

If inquiry-based instruction is being encouraged as an effective methodology, curricular materials using that method need to be evaluated. Yet, how can any curricular materials be evaluated if they are not being implemented to fidelity? How can the materials be implemented if educators are not properly trained, encouraged, and supported to do so?

Marshall et al. (2009) have been studying the barriers to educational change in teacher methodologies. Their specific focus has been transformation from traditional to constructivist methods with a spotlight on inquiry-based methods (Marshall et al., 2009). They call for additional research to investigate teacher self-efficacy in order to create interventions to boost self-efficacy in delivery of inquiry-based practices. More investigations are needed to address the relationship between subject matter knowledge and teacher behavior. Buehl and Fives (2009) also believe that the relationships between the belief about the source and stability of teacher knowledge and outcomes rooted to practice need to be further studied. This includes the extent to which teachers reflect on their practice, how much professional development they receive, and the teachers' engagement in the professional development. These activities may be examined to understand how teachers' beliefs are related to the teachers' responsiveness to the reform effort (Buehl & Fives, 2009). Finally, "studies need to address the quality learning that is transpiring in the classroom as well as how content and inquiry can be unified from a practitioner's perspective" (Marshall et al., 2009, p. 594).

This research generated a robust investigation of these barriers through interviews and surveys. The goal was to identify evidence of other barriers, and more importantly, to begin finding ways to overcome those barriers in order to effectively evaluate the inquiry-based program.

CHAPTER III

Methodology

Methodological Approach

In the application of mixed methods, as used in this study, Ridenour and Newman (2008) suggest the paradigms of quantitative and qualitative research are on a continuum, using the research problem as the driving focus for the research. They suggest the continuum can start with a theory and can lead to the development of a new theory, using a variety of qualitative and quantitative methods. Both methods may contribute to knowledge by examining causal arguments or defining questions about meaning.

The research question is fundamental in the research process and will determine the methodology. The focus is not on the methodological preferences of the researcher. In the social and behavioral sciences, quantitative data are considered explicit, controlled, and measureable, whereas the qualitative data are emergent, and less explicit (Ridenour & Newman, 2008). Quantitative and qualitative methods can complement each other to draw a better illustration of a phenomenon. Applying mixed methods, this research study used both qualitative and quantitative data to avail the strengths of both data sets.

This study followed the steps described by Collins, Onweugbuzie, and Sutton (2006), which begin with determining the goal of the study. The goal of this study was to better understand program implementation and evaluation, and to inform constituencies, such as the school district, administrators, the grant funders, and especially those establishing educational policy.

Research Questions

This study integrated qualitative and quantitative methods into a mixed methods approach, known as sequential explanatory design and used the following research questions developed in the process of a pilot study in 2012 (Creswell, 2009, 2012). The pilot study, carried out a year earlier in 2011, provided me with practice of interviewing skills and confidence in the developed interview questions. The pilot also informed the development of the initial research questions.

Research Questions: What are major barriers to a new inquiry-based science program being implemented and what are possible ways to overcome these barriers?

Supporting questions are:

- To what extent is the new science program being implemented to fidelity?
- What role does time play in the implementation of the new program?
- What roles do testing and accountability play in implementation of the new program?
- What roles do administrators play in implementation of the new program?
- What roles do teachers' beliefs and teaching philosophies play in the implementation of the new program?

These sub-questions will provide specific details to help answer the focus questions of this study. The literature provided insight for the development of these supporting questions.

Research Design and Rationale

The questions pertaining to what are major barriers to a new inquiry-based science program being implemented and what are possible ways to overcome these barriers were explored using mixed methods. The questions evolved from my observations throughout the first two years of program implementation. This research allowed the establishment of mental models as defined by Greene (2007) to see the phenomena through multiple lenses of caring, relationships, cultural sensitivity, beliefs, context, and professional experiences. Each of these lenses worked together to interpret and evaluate the program. In using quantitative methods alone, outside of the context of each teacher's situation, the analysis derived may have been skewed while conducting only interviews in the qualitative methods may have led me to generalize outlier interpretations of a phenomenon (Greene, 2007).

The specific mixed methods approach used in this research was the sequential explanatory study, because the data were collected sequentially with the first data set informing collection of the second data set (Creswell, 2009). The steps in this study for a sequential explanatory design: The pre-existing data of the teacher's self-reported highlighted lessons taught were used to define fidelity of implementation and to identify teachers for interviews, the open-ended questions from the teacher survey were used to develop final interview questions, the quantitative survey data was gathered, six teacher interviews were conducted, each data set was analyzed separately, and then data were merged to interpret across the sets to determine consistencies and conflicts in the data (Creswell, 2012).

In these steps, fidelity of implementation was defined using the teacher highlighted lessons. The anonymous survey of quantitative data and open-ended questions informed the modifications of the interview questions.

Research Context

The data represented a cross-section of interviews and surveys to create and interpret the story of a new inquiry-based science program implementation and its barriers, in an average sized rural school system in western North Carolina. The school system in this study consists of five feeder districts, each with one high school, one middle school and three to four elementary schools. There is also an early college and an alternative school for a total of 28 schools. This study involved all five of the middle schools and all 16 of the elementary schools because the 6^{th}grade is housed in the elementary schools.

Role of the Researcher

As the Science Curriculum Specialist in the district, I also wrote the grant that was funded and was responsible for the internal evaluation of the grant from the Golden Leaf Foundation and was required to gather quantitative and qualitative data for bi-annual reports for the three years of funding. Working closely with the Senior Vice President from the Golden Leaf Foundation, I was encouraged to gather more and more data to evaluate the overall project. This research study is only related to one part of the total grant funding, goals, and objectives. Other aspects of the grant entailed beginning Science, Technology, Engineering, and Math (STEM) tours for all 8^{th} grade students in the district, and growing afterschool STEM clubs and activities. The implementation of the SEPUP curriculum was the most challenging aspect of the grant. Although an outside evaluator was being used, I was responsible for focusing on my particular district and implementation. This study will be shared with the Golden Leaf Foundation for its records and to inform its future funding efforts.

In addition, I conducted all interviews, typed transcriptions of the interviews, created coding systems, and analyzed all data sets. For the grant and this study, I developed a working definition of fidelity of implementation, examined the barriers to implementation of the SEPUP program in the district and possible ways to overcome those barriers. This knowledge has helped me evaluate the implementation of the program, improve the program, and provide feedback to the funder and district.

The implementation has to be considered from multiple points of view, not just through my eyes as an experienced educator. The lenses I used were based on Greene's (2007) roles of caring, relationships, cultural sensitivity, beliefs, context, and professional experiences. Already having collegial relationships with all the science teachers in my district, some for many years, I could not approach this work without caring, understandings of my relationships with each individual and the knowledge I already had of the culture of each feeder district. Although I had a great deal of knowledge about the context of each school, the interview process revealed even more detail of which I was unaware. Each set of lenses offers new perspectives of the issue under study.

Ethical Issues

It is imperative to clarify the ethical issues in this research, especially pertaining to the researcher-interviewee relationship. I was in what may be perceived as an administrative or authoritative role with the interviewees, although I am classified as a teacher-on-special assignment and hold no position of authority. My work is to support my peers. As the writer of the grant who received funding for the new curriculum, I was acting as the local evaluator of the implementation of the program. Glesne (2011) states that the interviewer may be seen as holding power and status and suggests that the interviewer makes the interviewee aware that they are contributing to the research and being helpful. The interviewer needs to express a caring and grateful attitude and respond to interviewees anxiety (Glesne, 2011).

Most of the interviewees and survey participants have known me for many years and have worked with me in multiple capacities through emails and face-to-face conversations. Many of the teachers have been open with me during the last two years of implementation as to the successes and problems in the implementation. I responded regularly to inquiries with questions and suggestions of how best to implement the curriculum. In the process of recruiting the six interviewees, one teacher replied that he may not be a good candidate because he did not use the materials. In response I explained that I needed to interview those who did and did not use the curriculum to look for differences that determine the fidelity of implementation. Wanting to ensure he was truly comfortable with his decision, I made a short visit to explain the process and to observe any hesitancy. Understanding the interview was confidential and his name would not be used nor would it be provided to the administration, he appeared very open to participation.

In order to add anonymity to the process, all teachers were asked to participate in an online survey (administered by The Friday Institute), providing participants more freedom in their responses without the perception of my judgment. This data was collected prior to this study.

During interviews, I expressed appreciation for their participation regardless of responses. Individual responses from this survey were never shared, with identities attached, with administrators, other teachers, nor in any papers or reports. All participants were required to sign a consent form in order to participate in interviews, but at any time he/she could have chosen to withdraw from the project at which time their information would have been erased.

In order to address concerns of participant anonymity the recorded interviews remained on my password-protected computer and the names of participants and school sites were assigned an alias and the key remained on the computer. The alias identifications were destroyed and removed from the password-protected computer after printing of the dissertation.

Data Sources

Multiple data sources were used for this mixed methods approach to better understand the research problem and questions (Creswell, 2012). Table 1, as presented earlier, illustrates how each data source was used to address each research question.

Highlighted Lessons. I developed a working definition for fidelity of implementation after having all 6^{th}- 8^{th} grade science teachers highlight each lesson they taught from each unit provided in the SEPUP curriculum for their grade level(s). The SEPUP curriculum is both inquiry-based and issues-based. Each unit provides a real-life problem/issue. The students complete a series of integrated activities to learn the science to aid them in declaring defensible answers to the problem/issue. Many of the units are very long and may include large chunks of content not aligned with the state's standard course of study. The working definition of fidelity of implementation was created in light of the structure of the SEPUP curriculum. The first and the last activities framed the issue while at least one half of the activities were required to hold the story-line together for the issue. I encouraged the educators to try at least one new unit per year. In the third year of the grant, the teacher needed to meet this definition for two or more units.

The Friday Institute Survey Data. The Friday Institute of North Carolina State University gathered survey data utilized in this study as part of the evaluation of the STEM initiative for the Golden Leaf Foundation from 2012-2014. The schools and district sites that applied for and received funds from the Golden Leaf Foundation were required to participate in survey studies (Faber et al., 2013). All 6^{th}, 7^{th}, and 8^{th} grade science teachers were solicited to complete this survey over the duration of three years. The Friday Institute survey data (Faber et al., 2013) were collected specifically for the district in the summer of 2013.

Likert Scale Questions. Using descriptive statistics, questions making up the online survey, were arranged in constructs to describe teachers' self-efficacy beliefs and beliefs of outcome expectancy for their students. The T-STEM survey consisted of 11 questions pertaining to Personal STEM Teaching Efficacy and Beliefs Scale (PSTEBS) and nine questions of the STEM Teaching Outcome Expectancy Scale (STOES) that addressed science teaching efficacy beliefs and science teaching outcome expectancy beliefs respectively developed by the Friday Institute (Faber et al., 2013). These constructs were based on a five-point Likert scale and were used to describe the level of teacher self-efficacy and outcome expectancy in the population under study.

The Friday Institute began development of the surveys in the spring of 2011 through the Maximizing the Impact of STEM Outreach (MISO) research project. The Golden Leaf Foundation evaluation team worked with the MISO project team for the remainder of 2011 in the development of this survey. The pilot survey was implemented along with open-ended questions asking respondents for their suggestions of how to improve the survey from December 2011 to February 2012. Using the results of the pilot, The Friday Institute analyzed the instrument for validity and reliability to ensure that it measured what it was intended to measure, the power of the scales was appropriate, scales were functional across each unit, and scales functioned similarly across different types of teachers. The results were positive and only a few items were dropped from the survey when administered in year two from September 2012 to December 2012 (Faber et al., 2013). The validity was determined by assessing the survey responses in each pilot to find the questions with responses that were the most consistent and then using them to develop the constructs for the PTSEBS and STOES. The reliability of each construct was .908 and .814 respectively, using Cronbach's alpha measure of internal reliability (The Friday Institute, 2012).

***Open-ended Questions*.** Open-ended questions were also included in the survey. These were included to provide additional feedback to the grant funders. The questions included the following:

1. What successes have you had with the implementation of the SEPUP curriculum?
2. What barriers have you encountered in the implementation of the SEPUP curriculum?
3. What strategies have you or your colleagues used to overcome any barriers?
4. What part of the STEM effort in your school or district has been most beneficial to you?
5. What part of the STEM effort in your school district has been the least beneficial to you?

The responses provided anonymously to these questions helped to inform modifications of the initial interview questions.

Data Collection

The sequence of data collection was the following: Teacher self-reporting documents (highlighted lessons of every unit used by teacher) were used to define fidelity of implementation; pre-existing survey data received from The Friday Institute were used to modify interview questions; and interviews were carried out.

Identifying fidelity of implementation was important to program evaluation and answering the research questions. Fidelity of implementation was identified using teacher self-reports of lessons/units taught using the new science inquiry curriculum. After teachers completed these documents in the spring of 2013, I created a working definition of fidelity of implementation based on the teachers' self-reports. For this project, a teacher was classified as meeting fidelity of implementation if he/she used the introductory lesson, the final culminating lesson, and at least one-half the lessons for at least two of the units designated for their grade level. The definition was created considering the structure of the issues-based curriculum of SEPUP.

The surveys were forwarded to me in the summer of 2013 by the Friday Institute then relayed with the URL to all 6^{th}- 8^{th} grade science teachers in the district. The Friday Institute collected all data and forwarded them to me via Excel spreadsheet with all identifying data removed. I received only the questions with the raw data of corresponding responses for my district.

Using the open-ended responses from The Friday Institute, I modified the questions developed during the pilot for the research interviews. Creswell (2012) explains that this allows the first phase of the research to inform the second phase in explanatory sequential research. Onweugbuzie and Leech (2006) describe this process of informing as a development framework of mixed methods.

Participants

The six participants involved with the interviews were selected after determining which teachers had achieved fidelity of implementation (FOI) and which had not, based on my working definition. Table 2 shows how teachers were selected using stratified sampling (Creswell, 2012).

Table 2

Distribution of Interviewees across district

School by Feeder District	6th Grade Teacher: Housed in Elem School		7th Grade Teacher		8th Grade Teacher	
	FOI	**Not FOI**	**FOI**	**Not FOI**	**FOI**	**Not FOI**
A				**1**		**2**
B	**3**		**Middle School used in Pilot Study****			
C			*****			
D			**4**		**5**	
E		**6**	**Middle School Used in Pilot Study****			

** Two of the middle schools were used for a pilot study; these participants' data were not included. Therefore, the 7th and 8th grade teachers were selected from the other three middle schools in the district and the selected 6th grade teachers (housed in the district's elementary schools) were from elementary feeder schools of the two middle schools used in the pilot.
***Selected teacher opted out of interview

The teachers were identified by feeder area and whether or not they had achieved fidelity of implementation. In each grade level, one teacher achieving fidelity of implementation, and one not achieving fidelity of implementation were selected for the interviews. All teachers were put into columns by feeder area, fidelity of implementation and not achieving fidelity of implementation, and then by grade level. It was my goal to select teachers across all feeder areas so that each feeder district with unique characteristics might be represented. In the district some areas are more economically advantaged; others are more ethnically diverse. Four females and two males were interviewed to ensure teacher gender diversity. This allowed for the inclusion of at least one teacher from each feeder area in the district. One interviewee that was selected did not respond to multiple emails; therefore, one feeder area is not represented. The rest of the interviewees had already agreed to be interviewed and there was not another 7th grade teacher that had achieved fidelity of implementation in that feeder district.

Interview Protocol

After interviewees had been selected, they were contacted by email and provided with a copy of the consent form and goals of the study. Upon invitation to participate two of the six teachers replied that they did not want to participate because they did not use the curriculum, while three responded in agreement to participate. The sixth person did not respond to emails so another teacher was invited to participate and accepted. The two teachers declining the interviews expressed concern that they could not add to the research because they did not use the program. In response, I expressed that discovering why they did not use the program was also important to the study. They both then agreed and had much to offer in the interview process.

Interviews of two 6th grade, two 7th grade, and two 8th grade teachers were completed. The interviews were semi-structured (Glesne, 2011). The same questions (Appendix B) were used for each participant; depending on response, I often asked additional questions. The interviews lasting approximately 40-60 minutes were audio recorded and transcribed. Each interviewee was aware that he or she could withdraw at any time during the interview. The consent form can be found in Appendix C. Each person was interviewed only once since they already had access to materials for over a year and they were very familiar and comfortable with me, as explained in the ethics section.

IRB Procedures

This research project was approved by the Appalachian State University IRB, as well as the district’s IRB process prior to any interviews. During this process, I responded to all questions from the IRB in a timely manner. The IRB approval occurred in the fall of 2013 prior to any interviews.

Data Coding

Immediately after all six interviews were completed, I transcribed the recordings. The audio-recordings were loaded onto my computer, and then transcribed by me into scripts leaving a large margin on the right-hand side of the page for notes and coding (Creswell, 2012).

The terms *index* or *categorize* are used synonymously by some qualitative researchers for coding (Glesne, 2011). After reading the transcripts of the interviews in their entirety, categories or themes evolved. The transcripts were read again when coded notes representing the categories were written in the margins. The categories were used to create a matrix. Each category was placed down the left hand column, creating rows, and the interviewees going across the top in columns according to grade level and fidelity of implementation (Creswell, 2012; Glesne, 2011). The coded interviews were then used to complete the matrix. Open coding was used to place the relevant quotes appropriately into the matrix (Creswell, 2012).

Data Analysis

Each data set including highlighted lesson plans, Friday Institute data, and interviews, was analyzed uniquely. Each one will be discussed individually.

Highlighted lesson plans. The highlighted lesson plans were perused as they were turned in by each teacher via the district's courier system. Understanding that all the lesson plans in each unit would probably not be used, I had to create the operational definition of fidelity of implementation for the research project (Azano et al., 2011; Breitenstein et al., 2011; Harn et al., 2013). When reviewing the submissions, my observations over the last two years of those teachers claiming to use the curriculum were closely aligned with the documents matching the fidelity of implementation definition. The teachers who attained fidelity of implementation and those who did not were categorized by grade level prior to interviewee selections.

The Friday Institute Surveys. The Friday Institute surveys consisted of multiple constructs using the Likert scale and included open-ended questions pertaining to barriers of implementation. These data sets were analyzed separately.

Open-Ended Questions. After reading through all responses, categories were created that were repeated in the responses (Creswell, 2012; Glesne, 2011). All common responses were grouped together and counted. The responses with multiple references helped to modify the interview questions that were initially developed (Creswell, 2012).

Likert Scale Questions. Because teacher beliefs affect fidelity of implementation (Azano et al., 2011; Harn et al., 2013) the quantitative data gathered by The Friday Institute through the anonymous surveys were analyzed using descriptive statistics including general tendencies (mean), spread of scores (standard deviation-SD), and comparison studies (percentages) (Creswell, 2012). The Excel program was used to determine mean, standard deviation and percentages of the two construct sets of the teachers' self-efficacy, and outcome expectancies. Working with The Friday Institute, I cleaned the data set so that 24 participants' data were used for comparison. The mean of each question in each construct was calculated, and then the standard deviation for each question was calculated. It should be noted that inferential statistics were not applied since the survey participants were not selected randomly and there were so few respondents. Therefore, descriptive statistics were applied.

Interviews. After the matrix was created, the individual categories or codes were described using responses from interviewees (Glesne, 2011). The data were used to answer the question of "What is going on here?" along with the narrative zooming in and out to answer the research questions (Glesne, 2011). The data were summarized across the categories as they related to the research questions.

After each data set was analyzed, I zoomed out across all sets to examine generalities that were similar. As generalities were determined, conflicting data were also identified. This quantitative and qualitative data from the surveys and interviews were applied to complement each other and fill in the gaps that each one created when used alone. Each set of data was analyzed to tell part of the story of the implementation of the SEPUP science program in the rural North Carolina district and analyzed to see how all the pieces more completely describe the phenomena when viewed together.

Trustworthiness

Glesne (2011) poses four questions concerning trustworthiness: (1) what do you notice? (2) why do you notice what you notice? (3) how can you interpret what you notice? and (4) how can you know that your interpretation is the "right" one? She suggests using multiple data sets will help to establish trustworthiness. This is also evidenced in that my initial opinions were not all validated and yet were still included in the study (Glesne, 2011). I entered the project with opinions of the barriers heavily weighted in the deficit model of teacher beliefs, but the data did not validate those predictions consistently. I also reflected continually on my relationships with all participants in order to maintain professional respect for each educator and his or her beliefs and philosophies. Glesne (2011) suggests prolonged engagement with participants to validate interpretations. Although each interviewee was only interviewed once, I had worked with most of the participants several years, especially the last two years of the grant. The interactions have been in professional development settings, one-on-one trainings, demonstration lessons, and informal conversations. I have been on faculty with them, attending trainings with them and have been in their classrooms on many occasions. Many of them I consider friends. As I have shared the findings of this study with them, they appreciated that their voices and concerns were heard.

For added trustworthiness, many of the interpretations have been validated by the literature. I have also discussed the findings with The Friday Institute and professionals across the district. Trustworthiness was an important part of this study to help validate the data, especially in the interviews.

CHAPTER IV

Findings

This mixed-methods study was an evaluation of the implementation of an inquiry-based science program in a rural school system in 6^{th}- 8^{th} grades. Using the sequential explanatory study (Creswell, 2009), the two-phase process revealed general barriers to implementation of the new curriculum across a single rural district. The findings suggest possible ways to overcome those barriers for future program implementation.

Without fidelity of implementation, programs cannot be evaluated for effectiveness with validity or reliability. Hence, only after defining the fidelity of implementation through teacher-reported lesson delivery, the participants were selected to represent each feeder district and grade level. Using the pre-existing survey data from The Friday Institute, interview questions were finalized for study participants and themes were identified. The quantitative survey data (the Likert-Scale questions) were also used to compare teacher self-efficacy and outcome expectancy. This data asked questions pertaining to the teachers' self confidence in multiple areas and about their perceptions of when and why students achieve or do not achieve.

In this chapter the findings were described in the sequence in which they were collected and then the data were merged to answer each research question. The following data sets were analyzed: 1) the teacher highlighted lessons were used to define fidelity of implementation; 2) the on-line, open-ended responses were synthesized to modify interview questions; 3) the quantitative data from on-line surveys were analyzed for generalizations; 4) the six interviews were analyzed thematically, and 5) both qualitative and quantitative results were combined with the findings in six interviews to interpret the story of implementation of the SEPUP curriculum and to answer each research question.

Highlighted Lessons

In accordance with requirements of the grant funder and mandatory reports, teachers of science in 6^{th} – 8^{th} grades were required to submit a highlighted list of all the SEPUP lessons they had implemented in the previous year or planned to implement in the following year for each unit of study. Appendix A is a sample of one unit's lessons.

Referring to the highlighted documents, I determined the definition of fidelity of implementation to include the implementation of the introductory and the culminating lessons and at least one-half of the rest of the lessons in that unit. A teacher must have met these requirements for at least two of the units. A total of 50 teachers submitted the lists for 2012-13. Of those, 21 (42%) met the definition of fidelity of implementation, 16 (32%) did not meet the definition of fidelity of implementation, while 13 (26%) were new to the curriculum and, therefore, were excluded from the pool of potential interviewees. The highlighted documents were used to create Table 3. An inverse relationship between grade level taught and the number of teachers who were identified with fidelity of implementation (FOI) is evident. All 8^{th} grade science students must take the End-of-Grade assessment, while all the 7^{th} grade students and only one group of 6^{th} grade students are required to take the Measure of Student Learning (MSL) assessments (North Carolina State Board of Education, 2013).

Table 3

Numbers of 6^{th}- 8^{th} Grade Teachers Reaching FOI and Not Reaching FOI

Grade Level	FOI	Not FOI	New teachers to grade level, therefore not required to complete documents
6^{th}	**14**	**2**	**8**
7^{th}	**6**	**6**	**2**
8^{th}	**1**	**8**	**3**

Pre-Existing Data: Anonymous Online Survey

The survey was distributed by email, with the URL attached, to all 6^{th}- 8^{th} grade science teachers (47) during the summer of 2013. There were a total of 24 respondents, a 51% response rate. This survey was developed and vetted by the Friday Institute of North Carolina State University.

Open-ended questions. The responses on the open-ended questions yielded information related to the successes and barriers of the implementation of the SEPUP program and how some teachers worked to overcome those barriers. The responses were anonymous; all 6^{th}- 8^{th} grade science teachers in the district were invited to participate. These responses were used to inform the modifications of the interview questions. This survey data revealed the successes, barriers and ways in which some teachers overcame the barriers.

***Successes*.** Several comments on the survey noted appreciation for easy access to all the materials to do each activity while others mentioned the connection offered through the curriculum to real-world scenarios. Most of the comments about successes of implementation were clustered around the themes of *student interest, increase in skills of the student, and teacher and student collaboration*.

One teacher comment evaluated the success of the program stating that "SEPUP provides an excellent framework for real-world connections to science. Also, it is invaluable in teaching 21st century skills of collaboration, effective group interaction and communication." These life-skills are not readily taught in the traditional curricula available in the schools which indicate that this is one of the strengths of this curriculum when used effectively. Student interest and increased processing skills were noted multiple times in the survey indicating that these teachers believe these attributes to be important in the classroom as shared below:

> I feel that the kids are excited about science in my class with these kits. They love to work on the hands-on labs. I see them grow in their thought processing and using higher order thinking skills. I feel that the SEPUP curriculum allows me to easily integrate skills needed in other subject areas as well, which also makes my teammate happy.
>
> I have more hands-on activities and supplies ready to go taking a lot of the stress of preparation off my plate. I really think the kids enjoy the variation in reading materials as far as format. Obviously everything can't be a hands-on activity, but when they need to read information, it's not in a textbook format which can often be boring for the students. I know my kids are more interested in science when I'm teaching via SEPUP because they know there will be at least one hands-on activity each week.

It is interesting to note that many mentioned the readiness of the materials and ease of preparation as successful attributes; however, this was not the view of all the participants either on the survey or in the interviews.

Barriers. The two major themes related to the question about barriers to implementation are overwhelmingly *time* (time constraints were mentioned eight times) and *not being perfectly aligned with the NC Standard Course of Study (NCSOS)*. This alignment issue was added to the interview questions.

***Time*.** The comments referred to the time needed to set up the activities, time in class to do the activity effectively, and time to allow students to work together. One stated, "It is hard to guarantee such a chunk of time on a regular basis." It is not evident if this is related to the time allotted to teach science or only the time to do the activities. One participant was explicit about time for science instruction in that "Time constraints...I am responsible for teaching our Computer Curriculum, Science Curriculum, and Social Studies Curriculum. I get an hour and ten minutes with each group of students each day and I am responsible for covering all three areas." While this teacher teaches multiple subjects, another teaches multiple grade levels.

> I teach both 7^{th} and 8^{th} grade science and do not often have the time to set up multiple activities given the constraints of our school schedule. Many of the SEPUP units are time consuming and have to be edited so that the entire North Carolina Essential Standards content can be covered in the school year. SEPUP units often are missing content that is required by the Essential Standards and have to be supplemented.

The barrier of time required to implement the SEPUP curriculum is revealed in a variety of ways. In the responses, teachers were concerned with the time it takes to set up and carry out specific activities while others are struggling with time constraints because they have other subjects to teach apart from science, making preparation time for lesson planning and set up a struggle.

While some teachers have one hour every day to devote to the science curriculum, some have 50-90 minutes to devote to multiple curricula as described above. This is occurring mainly in the elementary schools, which house the 6th grade students and teachers. Many of these schools dedicate 90 minutes to reading, 90 minutes to math and 90 minutes to science, social studies, computer skills, remediation, etc. This time battle not only involves time of teacher with student, but time required for teachers to prepare for the class itself as echoed by Johnson (2006). Here the data appears to be conflicting. The number of 6th grade teachers who achieve fidelity of implementation are higher than the 7th and 8th grade teachers because there are almost double the number of teachers teaching 6th grade science along with other subjects. Therefore, while more than half of the teachers are readily implementing the curriculum, several of them do not because of being assessed in another subject and having little time to teach science.

Alignment. Teachers express concern that the SEPUP curriculum does not meet all their needs to address the North Carolina Standard Course of Study. Over the last two years, the teachers have met to work through all the activities to determine which lessons align with the North Carolina Standard Course of Study, which ones do not, and where the gaps are.

Overcoming barriers. Since some teachers consistently implement the SEPUP curriculum, while others do not, it was important to ask them how they were able to manage this under time constraints and the mandates of the North Carolina Standard Course of Study. While some responses suggested “trial and error,” working with the curriculum specialist, taking advantage of teacher circulation around the room and posting goals for the activities, the most common response was related to *teacher collaboration*.

Collaboration. One teacher stated "Collaboration - we work together and share materials so that no one person has to hunt down so many resources and create all the necessary documents." Another stated "We work together to supplement SEPUP with activities and content that address and clarify the standards." Because teacher collaboration was the predominate avenue for overcoming barriers, an interview question was developed to investigate this further. The collaboration seems to not only help with time barriers, but may even satisfy the emotional need to "talk out" what is going on and share frustrations as mentioned here:

> Working together with other 7^{th} grade science teachers to share lessons and ideas of what lessons work best within the units and how/what to supplement has really helped me to talk out any issues I have and overcome the obstacles.

While the district held several collaboration meetings over the span of the project, most success appears to have occurred where the teachers took the initiative to work together as professionals. They worked together to adjust class schedules and to help each other implement the program as mentioned in the surveys and interviews. They even worked together to supplement the program to meet the North Carolina Standard Course of Study gaps.

Support. It is interesting to note that when teachers were asked about what part of the STEM initiative has been the most beneficial, seven teachers stated that the SEPUP curriculum has been most beneficial by supplying all materials needed and by implementing a curriculum that was problem-based. One teacher even stated that the district-wide collaborative meetings were beneficial; another teacher stated that the administrator's support helped their school implement the curriculum.

As a result of these data, a few questions were added or adapted for the interview questions (Appendix B). Since there were so many concerns about the alignment, or lack thereof, with the North Carolina Standard Course of Study, a question about how well teachers felt the SEPUP curriculum is aligned and how they supplement the curriculum was added. Also, because of the many responses about teacher collaboration being one way to overcome barriers, a question was added about how their collaboration has evolved or not over the course of the implementation. The last question that was added focused on student engagement during SEPUP activities. This also revealed if student engagement was important to the teacher, which may relate to teacher beliefs and philosophies of teaching.

Interviewees selected. The final interview questions in the right-hand side of Appendix B were used for interviews with six teachers: two 6^{th} grade teachers, two 7^{th} grade teachers, and two 8^{th} grade teachers. Using the highlighted lessons submitted by each teacher, I solicited interviewees from each grade level who did and did not reach fidelity of implementation. Table 2 that illustrates these interviewees is found in Chapter 3.

Likert scale questions. These questions pertained to the teachers' beliefs and confidence in how they teach and about how their efforts affect student achievement. Since less than one-half of the teachers elected to participate in the surveys and they were not randomly selected, descriptive statistics were used to elicit general observations. In Tables 4 and 5, each question of the T-STEM survey is listed with their corresponding mean composite scores using the five-point Likert Scale and Standard Deviation (SD).

Table 4 reveals that the teachers being asked to implement SEPUP have a strong sense of self-efficacy. The mean responses ranged from 4.0 to 4.4 indicating teachers feel confident to teach science. Questions #2 and #4 are very similar and have the smallest variation evidenced by the smallest standard deviation of 0.55. Question #5 has the largest standard deviation of 1.04, but it is also the only question reverse coded. It is possible that in being the only negatively worded question, many teachers may have read it quickly and answered it incorrectly. This data point should be considered with reservation.

Table 4

STEM Teacher Self-Efficacy Beliefs (PSTEBS)

Questions Making up Construct of PSTEBS	M	SD
1. I am continually improving my science teaching practice.	4.4	0.71
2. I know the steps necessary to teach science effectively.	4.3	0.55
3. I am confident that I can explain to students why science experiments work.	4.3	0.74
4. I am confident that I can teach science effectively.	4.4	0.58
5. I wonder if I have the necessary skills to teach science.	4.0	1.04
6. I understand science concepts well enough to be effective in teaching science.	4.4	0.49
7. Given a choice, I would invite a colleague to evaluate my science teaching.	4.1	0.68
8. I am confident that I can answer students' science questions.	4.2	0.70
9. When a student has difficulty understanding a science concept, I am confident that I know how to help the student understand it better.	4.3	0.69
10. When teaching science, I am confident enough to welcome student questions.	4.4	0.71
11. I know what to do to increase student interest in science.	4.3	0.62

Note: Responses were recorded on a five-point Likert scale: "strongly disagree" (1), "disagree" (2), "neither agree nor disagree" (3), "agree (4), and "strongly agree" (5).

Table 5 reveals a different pattern related to Outcome Expectancy. Teachers did not appear as confident in their responses as evidenced by a mean composite Likert score of 3.3 for all questions.

The greatest variation was found for question #1 “When a student does better than usual in science, it is often because the teacher exerted a little extra effort,” with a standard deviation of 0.78. The smallest variation was found for question #2 “The inadequacy of a student’s science background can be overcome by good teaching.” Overall, there was less confidence in teachers’ ability to affect student outcome.

Table 5

STEM Teaching Outcome Expectancy Scale (STOES)

Questions Making up Construct of STOES	M	SD
1. When a student does better than usual in science, it is often because the teacher exerted a little extra effort.	3.4	0.78
2. The inadequacy of a student's science background can be overcome by good teaching.	3.5	0.66
3. When a student's learning in science is greater than expected, it is most often due to their teacher having found a more effective teaching approach.	3.7	0.69
4. The teacher is generally responsible for students' learning in science.	3.3	0.74
5. If students' learning in science is less than expected, it is most likely due to ineffective science teaching.	2.9	0.72

6. Student's learning in science is directly related to their teacher's effectiveness in science teaching.	3.3	0.74
7. When a low achieving child progresses more than expected in science, it is usually due to extra attention given by the teacher.	3.3	0.70
8. If parents comment that their child is showing more interest in science at school, it is probably due to the performance of the child's teacher.	3.4	0.71
9. Minimal student learning in science can generally be attributed to their teachers.	3.0	0.79

Note: Responses were recorded on a five-point Likert scale: "strongly disagree" (1), "disagree" (2), "neither agree nor disagree" (3), "agree (4), and "strongly agree" (5).

In Table 6, the teachers' self-efficacy is compared to their outcome expectancy by construct. Across the state and surveying 351 teachers, the PSTEBS score was 3.9 and the STOES score was 3.4 (Faber et al., 2013), yet the data set in Table 6 shows a larger gap between the two for this study. The district's mean data difference is 1.0 while the state's mean score difference is 0.5 between the self-efficacy and the outcome expectancy scores.

Table 6
Teacher Self-Efficacy and Beliefs (PSTEBS) and Outcome Expectancy (STOES)

Scale	Mean Composite Score (*N*=24)	Standard Deviation	State Mean Composite Score (*N*=351)	State Standard Deviation
Personal STEM Teacher Efficacy and Beliefs Scale (PSTEBS)	4.3	0.50	3.9	0.70*
STEM Teaching Outcome Expectancy (STOES)	3.3	0.49	3.4	0.75*

Note: Responses were recorded on a five-point Likert scale: "strongly disagree" (1), "disagree" (2), "neither agree nor disagree" (3), "agree (4), and "strongly agree" (5).
*(M. M. Faber, personal communication, February 9, 2014)

While the data suggest that teachers are confident in their abilities to teach science, they are still not as confident in effecting student outcomes. It must be noted that the teachers were not questioned about their instructional practices as related to inquiry instruction, but only how they perceive their abilities to teach science in general. Nor did the outcome expectancy construct simply the method of measuring student achievement. With this in mind, teachers may have only considered the standardized test results as a measure of student achievement and outcomes.

Analysis of the Interviews

In this section, interviewees will be introduced to add context to their responses. The teachers' background experiences and understandings of inquiry-based methods in the classroom provide a glimpse of their beliefs about teaching.

Interviewee introductions. All interviewees have worked closely with me, some for over 15 years. The least any of the participants has worked with me is two years. Their teaching experiences range from 4 to 24 years. The group of six teachers was composed of two males and four females. The teachers were identified by numbers 1-6; all will be referred to as "he."

Teacher #1 - 6th grade/FOI. With 14 years of teaching experience, he started in art education and is now teaching math and science in the 6th grade. When describing inquiry instruction, he referred to allowing students to "play" and develop "something that will mean something to them….more than me telling them what they are going to be doing."

Teacher #2 - 6th grade/Not FOI. With 14 years of teaching experience, he has taught a variety of subject areas and grade levels and has moved to North Carolina five years ago from teaching in another state. When describing inquiry instruction, he referred to it as students doing independent research and working on their own.

Teacher #3 - 7th grade/FOI. With four years of teaching experience, he comes from a family of educators and taught his first year outside of the country. When describing inquiry instruction he said, “Students ask their own questions and figure things out on their own” which is “the heart of inquiry-based learning.”

Teacher #4 - 7th grade/Not FOI. With 20 years of teaching experience, he was trained in biology, but has taught math the majority of his career. When describing inquiry instruction, he explained how he constantly asks students questions and encourages them to ask him questions.

Teacher #5 - 8th grade/FOI. With 24 years of teaching experience, he has taught in different districts and different schools and has also taught computer and math classes. When describing inquiry instruction, he describes how students form questions that may arise from the activity and “investigate those questions, sometimes with a lab, sometimes with discussions, sometimes with research.”

Teacher #6 - 8th grade/Not FOI. With 14 years of teaching experience, he entered education laterally with a biology degree through the North Carolina Teach program. When describing inquiry instruction, he describes it as “a balance between the control and letting them inquire, explore, and discover.”

Analysis of interviews by themes. The analysis of the interview transcriptions found the following recurring themes of barriers: *time (personal, face-time with students, and prep/clean up), testing influences, support (administration and curricular personnel), required curriculum, teacher beliefs/background, and others.* Each theme will be described separately and later compared to the data from the other sources. It becomes apparent that many of these themes influence each other, such as time to teach and administrative support.

Time. As predicted heavily in the literature (Agron et al., 2010; Feyzioğlu, 2012; Glickman et al., 2010; Johnson, 2006; Marshall et al., 2009; Oliva, 2009) and by my informal observations, time is the biggest barrier. Teacher #3 shared that many people held the misconception that the new science curriculum would save them time and, after the first year of working through it, found out it did not if they were doing many of the activities. Teachers # 3 and #4 shared openly that during the seasons they coach, they can do very little with SEPUP because every afternoon is busy with practice or games. Teacher #4 stated, "I have football and two daughters to take care of….It's just hard!"

Three teachers elaborated on the barrier of minimum face-time or class-time with students for science. Being in an elementary school for 6^{th} grade, they are the most pressed for science class time. Teacher #1 has only 30-40 minutes a day and the lessons are designed for 60-90 minutes, but he is implementing the curriculum by adapting the time of the lessons through student roles and procedures. Teacher # 2's teaching assignment was unique of the interviewees, but I know it is occurring in other parts of the district. Since he is in the elementary school and only has three teachers in the grade level, he has one hour to teach both science and social studies (he is only tested in social studies). He teaches reading through social studies and science is taught using independent study projects and choice boards or menus. When asked what he would do if he just taught science, he responded, "Oh, I would do them all the time. Yes, I would use those SEPUP kits all the time….I love the program. I think it is a wonderful way to teach."

Even though Teacher #6 does not use the materials to fidelity of implementation by definition, he does use several parts of several units. He expressed the frustration of not having enough time for each concept. While stating that some of the chemistry lessons (that are the most time-consuming to set up and clean up) are worth the understanding of the concept, he states, “I mean, for me, a lot of those activities are great, but you have to weigh it against, is it worth an entire class period for them to get that?”

Four of the six teachers interviewed shared concerns of the time required for prepping activities and clean up. Those who did not implement SEPUP shared that this is what they heard and understood from those who were implementing SEPUP. Teacher #4 said, “Time set up! I’ve heard from… one of the teachers who used it the first year…he stayed here until 5:30 every day, every single day.” I have seen first-hand the time required to set up for daily labs for some of the units, especially chemistry. Many of the activities involve using mineral oil and the clean-up is very time consuming.

Testing influences. The influence of testing was predominant in the interviews of two of the three teachers who were not reaching fidelity of implementation. As mentioned above, Teacher #2 is not focused on science instruction since he is being assessed in social studies. In North Carolina, teachers have to assess every student in at least one subject area (North Carolina State Board of Education, 2013). Since Teacher #2 is not being tested in science, his administration, along with his peer teachers are focusing on reading and social studies during the time designated for science. He stated that he would be helping the math teacher with his math during the science time, while some students would continue to work on independent science work and that some students needing remediation would not receive science instruction at all. Their focus is on the reading and math End-Of-Grade (EOG) tests and the social studies final exam. Since he teaches science and social studies and he only has to administer one test, the teacher and principal selected social studies. When Teacher #2 described the emphasis on testing he stated that testing in North Carolina "is the bread and butter, and the meat and potatoes of everything!" He compared the two states' policies saying, "We did not have to teach to the test at all. We did not teach that way. Whereas when I moved to North Carolina, I learned how to teach to the test."

Although the testing requirements are a clear barrier to the implementation of the SEPUP curriculum because of the schedule and time allotments at his school, Teacher #2 explained how the testing and accountability has caused him to be a better planner, planning his entire year at the beginning and making each lesson more compact and purposeful. He explained that he would use the kits if he had another science period or another person on his team.

Teacher #6, who must administer the 8th Grade End-Of-Grade assessment to his students, stated, "Just let me teach!" His frustration is related to the time allotted to teach the mandated curriculum for assessment. He states:

> I mean for me a lot of those activities are great, but you have to weigh it against, is it worth an entire class period for them to get that. . . . I think I probably start out stronger and do more, but then as that time crunch of EOG's approaches, I don't have a full day for some of those activities. . . . I don't have two days for them to get that concept. . . and the curriculum has expanded.

When asked if he would teach using more of the SEPUP materials if he was in the 7th grade, he responded positively. His frustration continued, stating that it is "hard because you don't want to feel like you are doing your kids a disservice if you don't get everything in."

Support. Support was reported in two categories: administrative and curricular personnel. Although all interviewees expressed appreciation for the curricular support of supplying materials, training, and support with refurbishing consumable materials, they all expressed the need for a set of SEPUP student textbooks that include all the lab activities and literacy strategies. They only received an online book to use with a projection camera and one hard copy. It is a frustration to have to make copies for students, and if the activity is more than one page long, it is not helpful to project it.

Teacher #6 expressed the concern that he did not believe most administrators supported the curriculum and that they are not encouraged to implement it. Although Teacher #2 did not express this, the administration helped design the plan that encourages and supports the social studies teaching and the independent science work.

Required curriculum. It is impossible to separate the required curriculum from testing, time, and support, but a few comments can be noted. The on-line survey revealed some teachers (five) were concerned that the curriculum was not totally aligned with the North Carolina Essential Standards for science; therefore a relevant question was added to the interview. In the interviews, five of the six teachers felt that many of the units were well aligned, but they believed that there were gaps in which they had to supplement. In 2011, the North Carolina Standard Course of Study was replaced with the Essential Standards, increasing the number of curricular topics at the tested grade levels. This was one of Teacher #6's main concerns. The sixth teacher had not yet used enough of the curriculum to form an opinion on the alignment.

Teacher beliefs/background. Findings suggest that teaching beliefs, self-efficacy/outcome efficacy, experience, and possible misunderstandings of the concept of inquiry-based instruction may influence implementation. These factors may also influence fidelity of implementation. If teachers do not believe inquiry-based instruction is profitable for student learning, they will not be willing to implement the method.

Teaching beliefs that were in conflict with moving to a new inquiry-based curriculum were revealed in statements such as, “It is easier to just walk in and do a PowerPoint…easier to do the same thing you’ve always done…not wanting to change…I feel more comfortable.” Teacher #6 discussed how it was really difficult during the first year of implementation trying the units for the first time because it was “not how we were used to.” He continued, “It’s a lot more comfortable now. I had to try them first and see how to make it fit my style of teaching.” Teacher #1 on the other hand, having a background in the arts described how his training of critique and design and his understanding of “play” naturally accepted the new curriculum. Yet, he expressed concern for the future of the science curriculum asking, “Are we going to continue this because I cannot imagine going back to a science textbook and trying to recreate every experiment?”

Although change of any kind causes frustration, Teacher #4 shared that he did not know where to go on the computer, could not find needed items for the activities, and seemed confused with the program as a whole. I sensed that he did not feel he would be able to use the curriculum effectively. He referenced his comfort and teaching preferences multiple times in the interview and had no plans to do any of the units.

Using the inquiry-based definitions and descriptors of National Science Teachers Association (2004), three of the interviewees (50%) shared evidence of lack of understanding or misconceptions. If teachers do not have an appropriate understanding of inquiry-based instruction, they do not understand the benefit to change instruction. Buehl and Fives (2009) state that if teaching experience is the only legitimate source of teacher knowledge then change will be difficult. In one instance, a teacher using the SEPUP to fidelity shared that on the third time using the curriculum; he finally understood the progression of the lessons. He thought the order had been done in error and had changed it for the last two years. He developed a more thorough understanding of how the order of the lessons aided students in discovering their own knowledge. If teacher beliefs and experiences are barriers, they must be acknowledged and considered in professional development for implementation of any new methodology or curriculum. This requires a great deal of time, training and sustained support.

Additional barriers. During the interviews, other barriers surfaced. Because the kits are shared among all of the 6th grade classrooms (5 sets of curriculum for 16 schools), both of the 6th grade interviewees shared frustrations at not having the kits in a sequential order and not being able to have them in whatever order they requested. The feeder areas met to create the rotation, but they had to share the kits and compromise in this process.

Teacher #3 shared another concern about teacher turnover that was specific to his school, yet this concern, also became prevalent in the 6th grade classrooms. In his school, he has been the only 7th grade teacher who remained. The other two teachers have changed each year over the past three years and Teacher #3 was not trained initially with the full day of training. As the elementary principals continue to move the teachers to various grade levels and teacher turnover continues, more time for training is needed. During the third year of implementation 13, or 26%, of the 6th- 8th grade teachers were new to the grade level or district.

Interpretation across Data Sets

All data from the interviews and the online survey were integrated into a matrix to find patterns of agreement and dissonance. The data was evaluated by research questions and supporting questions.

When implementing a new curriculum, what are the barriers that exist, as expressed by teachers? Of the many barriers that came forward, most were found in both data sets. Each barrier will be addressed in the following supporting research questions.

To what extent is the new science program being implemented to fidelity? Using my definition of fidelity of implementation, a teacher must use the introductory and concluding lessons and at least one-half of the lessons in the rest of the unit for at least two units. The following was noted: of the 50 teachers working in 6^{th}- 8^{th} grade science classrooms in the district, 21 (42%) of the teachers had reached fidelity of implementation for the SEPUP units, 16 (32%) of the teachers had not reached fidelity of implementation, but may be using some of the materials and lessons or not using them at all, and 13 (26%) of the teachers were new to the curriculum and were not included in the study. An inverse relationship is noted between grade level taught and the number of teachers identified as fidelity of implementation. This fact may imply the negative effect of testing and accountability policies, since the 8^{th} grade students are mandated to take End-of-Grade tests in science. In the 7^{th} grade, assessments, called Measures of Student Learning (MSLs), are now required while only some of the 6^{th} grade students have Measures of Student Learning for science. For each student taught by a teacher, that student must take at least one mandated assessment (North Carolina State Board of Education, 2013). Therefore, if a teacher has a student in a class for multiple subjects, only one area has to be tested. Since the math and reading are already mandated, most of the 6th grade teachers were not required to test in science.

What role does time play in the implementation of the new program? Time was the most predominant factor influencing teachers who either did or did not implement the SEPUP curriculum. Three aspects of time were mentioned: the time allowed for teaching science during the regular school day, the amount of time required to familiarize himself with the lesson and to set up and clean up the activities, and a teacher's personal time, which must necessarily be used due to the limitations of the school day. Whether teachers reported anonymously in an online survey or face-to-face in the interviews, the factors of time were predominant.

Time to teach science was the most pervasive barrier as teachers expressed in both data sets of the survey and the interviews how they have to teach multiple subjects in one period. In most of the elementary schools, the majority of the day is traditionally spent on reading and math. Often times, 90 minutes is allotted for reading, 90 minutes for math, and 60 minutes for rotations such as physical education, art, music, etc. The remaining time is spent on remediation sessions, science, social studies, health, computers, etc. These subjects are often put into one time block. This created a struggle for teachers of how much time to allow for "activities" versus how much content was required by the state curriculum.

Time required to prepare and clean up from the activities creating pressure was also evident in both sets of data. The chemistry unit, which required arduous preparation and cleanup time, was consistently mentioned. One teacher kept repeating in an interview that a peer remained at school each afternoon until 5:30 to clean up that day's unit and set up for the following day, while another mentioned in the survey that he taught both 7th and 8th grade science and did not have the time to set up for both of them if using SEPUP.

A teacher's personal time is at stake for the preparation and cleanup of implementing some units in SEPUP. With many teachers having to balance coaching and family responsibilities, the teacher has to make decisions about how to manage his time since time allotted during the school day is not sufficient for lesson preparations.

What roles do testing and accountability play in implementation of new programs? Second only to time, and yet related to it, are the testing and accountability policies of the state. The testing factor was predominant in the interviews, but it was not mentioned directly in the survey responses. The survey responses were indirectly related, such as teaching multiple subjects and integration of other tested subjects into their scheduled science time. As one teacher mentioned, "we [have] got to get reading scores up—whatever it takes" as he explained why he did not have direct science instruction but the students worked on independent projects if they were not receiving remediation. Another teacher explained that the implementation would be greater if he were not teaching 8th grade (which is tested with an End-of-Grade test). These test results are now are an integral part of the teacher's evaluation (North Carolina State Board of Education, 2013).

What roles do administrators play in implementation of new programs? Time for planning and time to teach are directly managed by the administration. The support of the administration and curriculum support personnel were common themes in both data sets. The curriculum specialist was perceived as helpful and supportive in professional development and provision of materials needed for all activities. The administrative support was perceived differently in both data sets. Some teachers shared that their administrator supported the curriculum while others stated that they did not feel supported by the administration in the implementation. The administrative support is indirectly noted in the scheduling of multiple classes during one period, time of the periods, and teacher allotments for teaching science. These factors were noted in both data sets.

What roles do teacher's beliefs and teaching philosophies play in the implementation of the new program? Teachers' beliefs, philosophies, and feelings of self-efficacy as well as outcome expectancies were common themes throughout the data, but not explicit. Teachers referred to whether or not the curriculum aligned with their own teaching style or how they did or did not feel comfortable. Some perceived that teachers went back to their own way of teaching after trying the SEPUP curriculum because it was what they were used to doing. These comments need to be considered when the quantitative data of teacher self-efficacy implied a strong confidence in teaching science. Teachers replied that they were confident in teaching science in the survey, but did not necessarily indicate they were using the SEPUP curriculum or using inquiry-based methods. The questions did not address inquiry instruction, only their perceptions of how able they were to provide science instruction. The teachers' beliefs about inquiry instruction were not addressed but in the interviews their misunderstandings of the instruction was evident. One teacher finally stated that he simply did not understand the new curriculum, and the interviews revealed that several of the interviewees could not readily explain or define inquiry-based methods.

Teachers' beliefs and philosophies can be seen in the following description. One teacher explained why his peer did not did not use the curriculum. The peer asked his students why he should use the SEPUP kits. They explained the activities would be fun and the peer teacher interpreted this comment as a waste of instructional time. When asked about students' engagement with the curriculum, the interviewees all admitted that students were more engaged with the SEPUP curriculum than other more traditional methods. One teacher explained that fun equals engagement. Another teacher with a background in art explained how his training and understanding of creative play was a natural fit for his use of the curriculum. Even if the teacher held a deficiency model for lower achieving students and explained how the curriculum was difficult for them, they readily agreed that the students were more engaged when using SEPUP.

How the SEPUP curriculum was aligned with the North Carolina Standard Course of Study was a variable in both data sets, but the data were inconclusive. The issue of the curriculum alignment with the state's required standard course of study was addressed negatively in the surveys. In the interviews, most teachers felt the units were well aligned but had gaps for which no units existed and they filled in those gaps.

What barriers may be overcome and how? The online surveys suggested that teacher collaboration was the answer to overcome some of the barriers such as time to prepare lessons, set-up time, short instructional periods, and adding curriculum for gaps in SEPUP. They mentioned they used Skype with professionals, worked with neighboring teachers in the same grade level, collaborated on scheduling, and worked with the curriculum specialist.

Since teacher collaboration was pervasive in the survey results, it was added to the interview questions. Teachers talked about how they use Dropbox.com (an online sharing tool) to work with other teachers across the district by sharing ideas and materials they created that align with SEPUP. Others were working with teachers in their building to work through the activities, sharing lab set ups, and student copies. Some described how they worked on flexible scheduling to get the activities completed. One stated how beneficial it was to have “another science teacher to work with and bounce questions.” Some teachers were working on integration of the units with teachers of different subjects. A few interviewees suggested having more time to meet within the school and across the district would be beneficial.

Summary of Findings

Whether teachers replied to an anonymous online survey or discussed the SEPUP curriculum in an interview setting, some generalities were discovered. The primary barriers for the implementation of the new inquiry-based SEPUP curriculum are: time for planning and preparing the activities in SEPUP, adequate time to meet all the required state objectives while using the curriculum, testing and accountability demands, support by administrators and curriculum personnel, and teacher beliefs and philosophies.

The predominant way to overcome many of these barriers is increased teacher collaboration. Time is needed to work with peers to plan and set up lessons/activities, share materials, work on flexible scheduling, and sometimes just talk through questions and concerns.

CHAPTER V

Conclusions

In this chapter, summations will be drawn on this study of the barriers to program implementation of a new inquiry-based science curriculum in an average sized rural school district. Summations will be discussed by analyzing the findings as compared to the literature, noting limitations of this study, stating possible implications of findings, and areas of further research needed.

Analysis of Findings and Literature

Although the barrier of time cannot be separated from testing or too many objectives in a mandated curriculum, it was found as the predominant barrier against the implementation of the new SEPUP inquiry-based science curriculum. This integration of time with other factors such as support and the mandated curriculum is related to the "coverage" of all the materials within a given timeframe (Agron et al., 2010; Feyzioğlu, 2012; Marshall et al., 2009). Teachers are required to "cover" all mandated objectives as stated in the North Carolina Standard Course of Study and each objective is represented by a specified percentage of each assessment. Understanding this, teachers have to make decisions daily about how much time to allot for specific objectives in order to fairly address the tested equivalents.

Time. Although the National Science Teacher Association (2004) continues to encourage the implementation of inquiry-based instruction, the integration of inquiry and content is not occurring because there is not enough time to develop student conceptual understandings (Azano et al., 2011; Quigley et al., 2011; Ratcliffe, 2004; Wallace, 2012). The frustration teachers expressed was found in both the online survey and the interviews.

Marshall et al. (2009) explain this frustration as a battle between teaching the required content and trying to do so in an inquiry-based manner. In reflection, the interviewees used phrases like “just let me teach” and “I don’t have a full day for some of those activities” and finally, “I mean, for me a lot of those activities are great but you have to weigh it against, is it worth an entire class period for them to get that?”

As Johnson (2006) discussed, the time it takes to do hands-on activities and learn a new curriculum or method steals from the teacher’s personal time. Within a typical class day, teachers are not afforded the time to properly plan, especially for multiple subjects or a new curriculum. Teachers already perform many duties beyond the daily responsibilities, such as faculty meetings, parent meetings, special nights/performances, and many take work home to grade or plan. Asking teachers to work towards implementing a new curriculum adds more stress by requiring more of their personal time when planning, training and collaborating are not built into the regular school day hours. As state teacher allotments are reduced each year, classes are getting larger and planning time cannot be extended during the regular school day. Until state and local policy makers see the importance of planning time and time for teacher collaboration, teachers are spending personal time collaborating and preparing lessons long after students leave the building if they plan to implement new methods and curriculum in a meaningful way.

In a professional development study in inquiry-based instruction, Banerjee (2013) found that it took a three-year cycle for teachers to learn and internalize the method well enough to transition to using inquiry-based instruction. The teachers in this study participated in 80 hours of training in the summer and in professional development that encouraged collaboration, but only during year three did the instructional methods begin to change in the classrooms. Banerjee (2013) also noted that the collaboration developed during the study, continued even after the funding had ended. The grant that is the focus of this research project has also been supported for three years. The collaboration that has developed may encourage the sustainability of the curriculum, but those schools and teachers who have not developed a process of collaboration will probably never use the curriculum.

Testing. The conflict of "coverage" of the concepts required by the state is magnified by the continual increased consequences regarding high-stakes testing and accountability. In one study, Wallace (2012) explained how high stakes testing influenced her practice. She was strongly encouraged to change her inquiry-based teaching methods to align with the methods of other teachers getting higher test scores. It is evident how influential the test scores were and still are. Beginning this year in North Carolina, teachers are now evaluated by how their students perform on the End-Of-Grade tests and Measures of Student Learning assessments (North Carolina State Board of Education, 2013). Teachers' growth scores are automatically calculated and inserted into their electronically stored evaluation instrument. The schools' scores are also calculated and inserted into the administrators' electronically stored evaluation instrument. Not only does the high-stakes pressure come from the requirements of the Department of Public Instruction, but even closer to home; the school principal also adds to the high stakes performance pressure. The students' testing scores directly influence the administrators' evaluation scores. While these tests keep growing in number and impact, Ornstein and Hunkins (2004) are concerned that the focus on multiple-choice tests is not preparing students for problem-solving in a future that is generally complicated by relationships, stress, and situational crisis.

Over the last several years, I have listened to local businessmen and sat in countless meetings where there is great concern surrounding work-force development. Business representatives are constantly reiterating how they need a work-force that can problem-solve and be creative. However, none of the schools' assessments measure these attributes, especially on multiple-choice tests. This suggests a misalignment between what schools are assessing and what skills community business leaders suggest are needed for our future workforce. Testing and accountability have a greater influence on instructional decisions than do community business leaders' requests.

Administrative support. The "elephant in the room," described by Johnson (2006) was confirmed in both data sets. The "elephant" is the fact that teachers have to spend time that should be set aside for non-tested subjects, such as science to prepare students for assessments in math and language arts. In an interview, Teacher #5 spoke in great detail about why he did not implement the SEPUP kits. Although he was appointed to teach science and social studies, only the social studies curriculum was tested both last year and this year for 6^{th} grade at his school. The students are assigned independent science projects if they are not being remediated for math in the afternoon. It should be noted that the administration was in support of his plan of action and helped make these decisions. Marshall et al. (2009) state that administrative support is crucial for successful implementation of programs. Since the teachers only have to test students for one subject to meet the requirements of their evaluation tool, some have a choice of what to test, and therefore a choice of what they can emphasize instructionally (North Carolina State Board of Education, 2013). Indirectly, the lack of administrative support for the curriculum implementation was also revealed in the survey. One teacher discussed this lack of support by describing how she had to teach science, social studies, and computers in a 70 minute period, and another teacher expressed that the preparation time for teaching both 7th and 8th grade science was too great. They both had to make instructional decisions as to what subject would get the most attention, probably the one being tested that year. If science is not being tested, the science time is being used to remediate and teach the tested subjects (Johnson, 2006).

Teacher beliefs and philosophies. In the analyses, teacher beliefs, self-efficacy, and experience were all grouped together as intrinsic factors. Previously discussed barriers were outside the teachers' control, while the intrinsic barriers come from within each teacher. Teachers bring their beliefs, self-efficacy, and experience into the classroom every day, despite whether the extrinsic circumstances change or not. The literature describes each one of these intrinsic barriers. Feyzioğlu (2012) posits that teachers will revert to their traditional methods of teaching when encountering difficulties. This insight is upheld in the interview data. Three interviewees discussed how many teachers reverted back to their traditional teaching methods during the first year of implementation as they became frustrated by the required time and struggled with new activities. They found the traditional methods more manageable. One teacher also commented that teachers didn't want to do things differently and wanted to do them the way they had always done them.

In the literature, it is noted that the suggested change may be in conflict with a teacher's teaching style (Glickman et al., 2010; Oliva, 2009). The change cannot be forced and takes time, but Haney et al. (2003) explain that a teacher's beliefs about what works best in a classroom may never change because those beliefs are formed so early in life. Many of those beliefs are substantiated in their pre-service experiences. Two teachers explained how they were taught traditional methods during their pre-service years in college. After discussing his understanding of inquiry-based science, a teacher stated, "I did not learn anything about any of this [inquiry-based instruction] in school in my undergrad degree." Another stated, "It's moving away from what I was trained in and what was comfortable, which were just the experiments which you know and know how they're going to come out." These statements verify the need for extensive professional development for any methodological changes to occur. Time is necessary for people to attempt to change, and time is needed to allow teachers and administrators to contribute and be a part of the change. Forcing a teacher into immediate change that may be in conflict with her teaching style is counter-productive (Glickman et al., 2010; Oliva, 2009). A strategic plan is necessary to accommodate the time for extensive professional development, trial and error, collaboration, and personal assessment needed for individual changes to lead to systemic change. Throughout the change process, sustained support is necessary.

While I have observed frustration from many teachers throughout the implementation, I believe that this is related to teacher self-efficacy. One teacher discussed how he did not think he could make this curriculum work in his classroom. He could not grasp how to implement the inquiry-based curriculum and finally expressed that he just did not understand it, revealing a lack of self-efficacy. He may also have had a misunderstanding of inquiry-based instruction. I propose that if teachers do not hold a strong understanding of inquiry-based instruction, they may not see the need to implement a program such as SEPUP. It may be in conflict with what they know or understand as best for students.

Teacher collaboration. As the data were being collected, it was refreshing to learn that the most noted way to overcome the barriers of time, testing and accountability, mandated standards that are too inclusive, and even lack of administrative support, was through teacher collaboration. In both data sets, teacher collaboration was repeatedly noted as the means by which teachers implemented the new SEPUP curriculum. Although they had support from the curriculum specialist, the most beneficial support was found within their schools, next door or across the hall. Policy makers, grant funders, and administrators need to realize that time and funding must be granted to allow teachers to work together to implement new strategies, curricula, and programs. Additional funding is needed to allow release time for teachers to work and plan together. This may be paid time in the summer for collaboration or additional workdays to plan implementation and work through issues that develop during the implementation. Time and funding provide a better chance for programs to be implemented to fidelity, and then evaluated for student impact.

Several of the teachers commented in both data sets that the district-wide sharing sessions that specifically focused on the SEPUP curriculum, the alignment of SEPUP with the North Carolina standard course of study, and the helpful tips and suggestions were all beneficial in the implementation classrooms. The type of collaboration that seemed to make the biggest difference in implementation was the one-on-one, teacher-to-teacher help within schools. Peer teachers helped each other and supported each other. On the survey one mentioned "talking it out" as helpful. In order to encourage more of this in-school collaboration, administrators need to build in this time for teachers to talk about the implementation to show overall support for the reform (Bond et al., 2009; Chin-Chung & Ching-Sing, 2012; Johnson, 2012).

When teachers collaborate, teacher self-efficacy may be increased as teachers openly discuss issues related to program implementation. During their dialogues, the concerns of measuring student achievement could also be addressed. The quantitative data revealed that teachers had a mean composite score of 4.3 on the PSTEBS questions compared to a score of 3.3 on the STOES set of questions. This difference implies that although the teachers surveyed were confident in their teaching skills, they held some reservations about how effective they believed they were in reaching all students. This data set is similar to the data set created by the Friday Institute for 14 different grants, of which this project is one. Both data sets showed a higher mean of self-efficacy and a lower mean of outcome expectancy (Faber et al., 2013).

Lakshmanan et al. (2011) explain that multiple studies supported the relationship between teachers' self-efficacy, outcome expectancy, and student growth in achievement. The teachers in this study had confidence in their ability, but not in the fact that they could consistently impact student achievement. The survey data indicate some teachers believed that some students were not able to learn from inquiry instruction; therefore, those teachers would not implement the curriculum. The curriculum cannot affect student achievement if it is not used.

Limitations

This study had several limitations. Only six teachers were interviewed and almost one-half of the teachers in the district did not respond to the online survey; therefore, all teacher perspectives were not assessed. Other stakeholders' perspectives such as administrators, students, support personnel, parents, and community members, were not considered in this study.

The context of the curriculum change was also a limiting factor. Since the grant submission process was under a strict timeline, little opportunity was available to survey teachers and prepare them or the administrators. Oliva (2009) claims that curriculum changes result in changes in people, and that one must begin working with the people prior to the curriculum change. If the teachers have a lack of enthusiasm and no opportunity to contribute to the change, acceptance is not likely. This study cannot be compared to a curricular change when time and opportunities of teacher preparation and contribution have been implemented.

Implications

The major implications of this study are two-fold. First, the findings related to barriers to implementation point to the fact that educational policies are restraining the systemic improvement of educational practices with the requirement of high-stakes testing that inhibits teachers' time and autonomy. The second major implication, however, focuses on how those educators who do implement to fidelity and continue to work against the pressures of testing to improve their practices, do so by collaborating with peers. The implications for stakeholders will be how they are able to arrange and encourage teacher collaboration.

Walker (2013), speaking for the National Education Association, shares concerns related to testing that are echoed in the findings of this research. Representing the most powerful education lobbying organization, he states that testing programs have

> caused considerable collateral damage in too many schools, including narrowing the curriculum, teaching to the test, reducing the love of learning, pushing students out of school, driving excellent teachers out of the profession, and undermining the school's climate. (p. 41)

Findings in this study can support this perspective. Several of the teachers commented that although they and the students loved the curriculum, they had to limit its use in order to prepare for the tests. They expressed their concern over the pressure to cover the content. The conflict between what is expected of educators and what educators see as best practices does exist. Teachers have to weigh the time needed to create deep understanding of concepts with the percentage each objective represents on the standardized tests along with the number of objectives to be taught. Several keystone educational policies have worked together to create this conflicting environment, pitting inquiry-based learning strategies against the demands of standardized testing. Those policies are: the federal legislation of No Child Left Behind (King & Rohmer-Hirt, 2011), the North Carolina Teacher Evaluation Process (NCTEP) (North Carolina State Board of Education, 2012), and the competitive federal Race to the Top (RttT) (Duncan, 2009) grant funding received by North Carolina. While each policy appears to focus on a quality education for every child, Ryan and Cousins (2009) posit that the accountability models are really intended for re-establishing the public trust in government and applying evidence in anchoring policy and decision making. So the focus of each policy is assessing student achievement and learning with standardized testing, rather than focusing on improved instructional strategies. This misalignment of goals and the assessments that measure those goals is obvious as exemplified in the descriptors for teachers as 21st century educators which are used for teacher evaluation in the North Carolina Teacher Evaluation Process (North Carolina State Board of Education, 2012):

- Teachers can no longer cover material; they, along with their students, uncover solutions. They teach existing core content that is revised to include skills like critical thinking, problem-solving, and information and communication technology literacy.

- In their classrooms, teachers facilitate instruction encouraging all students to use 21st century skills so they discover how to learn, innovate, collaborate and communicate their ideas.
- Subjects and related projects are integrated among disciplines and involve relationships with the home and community. (North Carolina State Board of Education, p. 7)

These descriptors in this teacher evaluation tool can be aligned with inquiry-based instruction, applying the theory of constructivism and allowing students to explore, question, test, collaborate, and make learning relevant. These descriptors can also be used to describe the implementation of the SEPUP curriculum. Yet, the North Carolina Teacher Evaluation Process instrument contains six distinct standards with the final standard being: "Teachers Contribute to the Academic Success of Students." This standard is measured in that, "the work of the teacher results in acceptable, measurable progress for students based on established performance expectations using appropriate data to demonstrate growth" North Carolina State Board of Education, 2012, p. 12). The data used for this standard are the End-of-Grade, End-of-Course, and MSLs which are all multiple-choice tests. These types of assessments are not adequately measuring any of the descriptors used to describe effective teaching found in the North Carolina Teacher Evaluation Process document. There appears to be a misalignment between what the policies are describing as effective teaching and how it is being measured.

North Carolina was obligated to uphold the No Child Left Behind national policy, and had already adopted the new North Carolina Teacher Evaluation Process and then applied for and was awarded the federal grant for Race to the Top. The Secretary of the Department of Education, Duncan (2009) explained the impetus for the Race to the Top initiative, as follows:

> Through the Council of Chief State School Officers, 46 states and three territories have agreed to work on a common core of internationally benchmarked standards. This is just a first step, but it is a huge step in the right direction.
>
> We absolutely support that work because we know from the data that the Trends in International Mathematics and Science Study (TIMSS) and the Program for International Student Assessment (PISA) study that America has stagnated educationally as the rest of the world has progressed and in too many places passed us by.
>
> We're competing with children from around the globe for jobs of the future. It's no longer the next state or the next region. It's India, China, South Korea, and Finland. (para. 29-31)

According to Duncan (2009), Race to the Top is a competitive grant for millions of dollars to improve instruction by creating a standardized, national curriculum that can be assessed consistently across the nation with the goal of out-performing other nations. This program was developed in response to the concerns of the Committee on Prospering in the Global Economy of the 21st Century (Augustine, 2007) claiming that the United States is losing its competitive edge. Being awarded the Race to the Top grant, North Carolina adopted the common standard curricula of the Common Core State Standards and increased the number of tested areas already required under No Child Left Behind, to meet the requirements of the grant. These additional tests are multiple-choice tests as well. The effects of increased high-stakes testing are evident in the inverse relationship between the grade levels and the numbers of teachers reaching fidelity of implementation, which is apparent in the data. While sixteen 6th grade science teachers reached fidelity of implementation, and six 7th grade science teachers reached fidelity of implementation, only one 8th grade science teacher achieved fidelity of implementation. This data correlates to the emphasis on standardized tests. The 8th grade science has had mandated standardized testing for many years. Most of the 6th grade teachers were not required to administer the science assessment (North Carolina State Board of Education, 2013). The practices of high-stakes testing continue to place more emphasis on assessments than learning in order to solicit confidence in the education system and the government's efforts.

New, more comprehensive assessments are being developed through Race to the Top funding, known as Smarter Balance and PARCCS (Smarter Balances Assessment, 2012; Partnership for Assessment of Readiness for College and Careers, 2014). They offer a more comprehensive program of assessment by establishing online tests that vary with each response. A participant's response dictates the types of additional questions asked. When fully developed, states will have to decide whether or not to purchase these programs for nearly $30 per student. It is not yet apparent whether the state will select to move to the new more comprehensive assessments that may provide more correlation between effective teaching strategies and measurement of student learning.

Each policy, No Child Left Behind, North Carolina Teacher Evaluation Process, and Race to the Top mandates standardized testing for all students so that students will be able to score above students in other nations. Yet these policies express the need for improvement of instructional practices that should lead to more comprehensive student achievement. Policy makers need to consider the mixed messages they are sending with these mandates. This research reveals an apparent conflict, perceived by teachers, between inquiry-based methods of teaching and the state's methods of assessing student learning. With each newly legislated policy emphasizing more high-stakes testing, teachers do not see the policies encouraging a shift to more inquiry-based methods. Yet, teachers strive to meet all mandates, although they are constantly changing with each new legislative session.

This study identified teachers who were able to implement the new inquiry-based curriculum, even while they struggled with the demands of testing. Many did so, especially in the 6^{th} grade, because students are not tested in science. Others were able to do so through working daily with colleagues. In both the surveys and interviews, teachers described how they worked with teachers across the hall, or in their same grade level, to prepare the lessons, copies of the student activities, and even alter daily schedules when needed. This implies that (a) the system is challenging teachers' autonomy to create and implement engaging lessons, and (b) collaboration can be an approach to overcoming barriers.

The findings from this study indicate that when new curricula, programs, and methods are being implemented, time for teacher collaboration should be a consideration in reform planning. Educational policy, grant funders, school systems, and school administrators need to understand time for teachers to collaborate is not optional, but a requirement if fidelity is to be achieved. While professional learning communities (PLCs) are formal options and may begin establishing a positive climate for teacher collaboration, this research revealed that collaboration among teachers seemed successful when it was informal. Teacher collaboration can be achieved by establishing time and a climate within a school or system. Administrators set the expectation of collaboration by modeling teacher collaboration in faculty, grade level, and department meetings.

It should also be noted that one teacher did discuss how the mandated testing forced him to focus on the curriculum he was tasked to teach and prompted him to plan the year more efficiently in order to teach all objectives. This particular teacher, who did not implement the new curriculum, collaborated on a daily basis with his colleagues to teach the objectives of the subjects for which the students were tested. While the science objectives were not being taught, the teachers did work collaboratively together to teach the tested subjects. A positive climate was established for teachers to discuss planning regularly.

With those stated, educational policies comparing teachers' student scores against colleagues' students' scores is counter-productive to building a collaborative climate. In the latest North Carolina legislation (North Carolina State Board of Education, 2013), the school board of each Local Education Agency (LEA) has been mandated to select 25% of the district's top teachers to receive bonuses (which may be based on test scores), in exchange for signing and waiving their due-process rights. Under such conditions, it appears that collegiality is not being encouraged.

The most fundamental implications of this study can be addressed to educational leaders and policy makers who strive to improve student learning through effective instructional practice. Questions that must be addressed when writing and implementing policy are:

- How does increasing the number of standardized assessments improve education?
- Do the instruments assess the kind of student learning and skills that will help them be successful in the world that is changing daily?
- Are these policies building a climate that encourages educators to work together to improve instruction for all students?

- Can fidelity of implementation of new programs, curricula, and methods be expected in the face of high-stake standardized testing?
- How can the policies encourage and build support systems for increasing teacher collaboration?

The findings of this study also have implications for teacher education programs. While more progressive teacher education programs are implementing inquiry-based instruction in the classes at the university, others are not. Most of those teachers interviewed said they had not been trained in inquiry-based methods, but the few who had, more readily implemented the SEPUP curriculum. The implications are even greater when assessing the universities' teacher education programs for high school teachers because they receive most of the training outside the education department. Most of professors of the faculties in the arts and sciences have never been trained in educational methods, and rarely in inquiry-based methods. If research continues to imply that inquiry-based methods are effective ways for teaching and learning, should the universities' professors also be trained in and implement the methods?

On a local level, this study was carried out according to the purposes described by Greene (2007). The first purpose of program evaluations is to assist policy makers in decision making as discussed previously. Secondly, the goal of program evaluation is continued improvement of the implementation. Since the collection of these data, another full day of teacher training and collaboration has been held. All 6^{th}- 8^{th} grade science teachers met to complete a new inquiry-based unit together. Working together through this unit, they created a list of characteristics of inquiry-based instruction. In the afternoon, they worked together in grade levels to re-evaluate each SEPUP lesson and its alignment with the standard course of study and also shared ideas and resources for filling the gaps in the SEPUP curriculum.

The next purpose of developing a deeper understanding of the program and practices has occurred for the teachers and me. This study has been beneficial to all participants because of its necessary and demanding requirement for stakeholders to make time to meet together for dialogue. The teachers seemed to appreciate the opportunity to work together to create a better understanding of inquiry-based instruction, and I learned more details about the context in which many of the teachers work.

Finally, another purpose of program evaluation is to improve the justice and equity of the program under study. This is also being carried out on a daily basis as I continue to encourage teachers to use the SEPUP curriculum with all students, especially those most in need for more interactive learning methods.

Overall, this project added data to the literature involving barriers to implementation of inquiry-based instruction, and ways those barriers may be overcome. It also addressed the conflict between how teachers are encouraged to teach and how they are assessed.

The process of this study was the most challenging professional development of my career. Like Greene (2007), I had to focus my lenses of caring, relationships, cultural sensitivity, beliefs, context, and professional experience. While I am a strong proponent of inquiry-based instruction because of my professional experiences, I had to be sensitive to the beliefs and experiences of each teacher. Although I knew a great deal about most of the cultural differences at each school, each interview helped me focus on the fact that those differences had to always be considered with changes in the curriculum.

After working so closely with these teachers, I have a greater understanding of the context of many different schools and classrooms, which may allow me better insight to work with principals. In the future, when preparing for systemic changes and changes in methodological practices, I would have to warn administrators of the barriers and to encourage them to consider building a climate to enhance teacher collaboration and providing extensive support in order for the changes to be implemented. I have already been working with a principal who wants his faculty to implement more inquiry-based learning and we have discussed these barriers and the need for teacher collaboration. He wants his teachers to try just one of the SEPUP units completely, especially his 8th grade teachers who believe that it will hinder strong student test scores.

By conducting this study, I have started to develop into an educational leader. As I continue to work to influence more effective science education, I believe constructivist approaches, such as inquiry-based instruction and the SEPUP curriculum, help students make personal connections with their natural world and learning becomes relevant.

Further Research

Since these findings brought time, curriculum, and testing to the center stage for analysis, further research may need to focus on tested areas of the curriculum. Repeatedly, the accountability model seemed to hinder the implementation of the new inquiry-based science curriculum. Further research is needed in the tested areas such as reading and math to determine if inquiry-based methods can increase student achievement as measured in multiple-choice tests. Additional research needs to be implemented to develop assessment tools to measure other process skills and science behaviors as well. More research also needs to be conducted from the students' perspective. How are they processing the science activities, discussions, and content?

Although this study validated the barriers to implementation that aligned with the literature, the meaning of fidelity of implementation is still not clear. This project only investigated the surface category of fidelity of implementation as described by Harn et al. (2013), such as number of lessons taught and use of introductory and culminating activities. The second category of process is the quality of lesson delivery and student-teacher interactions. These variables were never evaluated because of the time required for the study through many observations. As the quality of the lessons is evaluated, a researcher could then observe how the flexible definition of fidelity of implementation to meet students' needs can be researched as well.

In the interviews, several teachers discussed how they changed lessons to meet students' exceptionalities and background experiences. Further research is needed to capture and understand the expertise a teacher uses to implement a specific curriculum in a way that meets students where they are. If fidelity of implementation can be determined and sustained, then student achievement can be studied and assessed more accurately.

In conclusion, the future implementation of inquiry-based instruction requires a paradigmatic change, that leads educators, researchers, and policy makers to the agreement that the professional development needed for such a change is complex, expensive, and long-term (Pea & Wojnowski, 2014). As the National Research Council (2012) and National Science Teachers Association (2004) call for the move to more inquiry-based instruction the cost has to be addressed as does as the traditional means of testing and accountability. Yager

(2011) comments on the struggle of change from the understanding of what inquiry-based science is:

> Why is there not more attention to all students (and teachers) actually “doing” science in every K-16 science classroom? The faulty assumption is that there is information thought to be accurate that all must “know” *before* “doing” science. Doing science means personal exploration of nature and attempting to explain objects and events encountered….Science cannot be done in a vacuum! It takes doing, trying, thinking creatively, and gathering evidence! Textbooks, lab manuals, and quick fixes are all the opposite of actually “doing” science. (p. 62)

Traditional teaching is safe. It is the way teachers were taught and the way they often are taught to teach. Inquiry-based instruction is not new, but it struggles to find its way into the mainstream of everyday teaching in classrooms. It is what stakeholders call for, but not what teachers are held accountable for. There is a misalignment between what is desired and what is measured.

Can any of these barriers be overcome? According to the findings of this research, teachers have direct control of only one possible way to overcome the barriers of program implementation—teacher collaboration. If schools, districts, and states would see all the expertise teachers can share with one another on a regular basis, the implementation of new programs may have a better chance at full implementation. Once fidelity of implementation occurs, then and only then, can the effects of student achievement ever really be measured. Student learning should increase as teachers learn together in a sustainable way.

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Appendix A

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UNIT G: BIOENGINEERING

Listed below is a summary of the activities in this unit. Note that the total teaching time is listed as 18–22 periods (approximately 4–5 weeks). If you find that you are unable to approach this timeline, consider skipping one or more of the following activities: 105 or 106.

	ACTIVITY DESCRIPTION	KEY CONCEPTS AND PROCESSES	ADVANCE PREPARATION	ASSESSMENT	TEACHING PERIODS
102	**INVESTIGATION: You, An Inventor?** By simulating injuries to the dominant arm, students invent solutions to problems they encounter accomplishing common tasks.	invention, strategy, technology, tool	need cutlery, clothing, toothbrush, toothpaste, hair clips, doll, glue, scissors, tape, boxes, games; set up stations; copy student sheet		2
103	**READING: Bioengineering Case Studies** Students read about four individuals who used strategies and tools to address problems resulting from disabilities.	strategy, tool, prosthesis			1
104	**IPROJECT: Designing Artificial Heart Valves** Students design and construct prototypes for replacement heart valves.	control, variable, prototype, aorta, valve	need sponges, mops, sandwich bags, scissors, tape, colored pencils; construct sample valves; copy student sheets	Proc: DI Proc: GI	3
105	**PROJECT: Boning Up on Design** Students design and construct artificial bones as they investigate the relationship between structure and strength.	control, variable, prototype, mass	need plastic bags with twist ties, tape; copy student sheets	Proc: DI Proc: GI Proc: CS	3–4
106	**LABORATORY: Investigating Natural Structures** Students continue to explore structure and function as they dissect a chicken wing. [This is a repeat of Part A of Act 16]	structure, function, tendon	buy chicken wings; need bleach, forceps, dissection scissors and trays	Q2: RE	1–2
107	**INVESTIGATION: Balancing Act** Students explore the use of and need for Calories as they design and produce edible energy bars.	Calories, exercise and nutrition, qualitative, quantitative, trade-offs	need multiple food items, measuring spoons, measuring cups, plastic cutlery, sandwich bags; copy student sheet	Proc: GI Q4: ET	3–4
108	**TALKING IT OVER: Technology and the Life Sciences** Students discuss the work of 16 individuals who have made contributions to bioengineering.	invention, engineering, science, technology	copy student sheet	Quick Check Q3: ET	2
109	**PROJECT: Getting a Hold on Design** Students design and construct a mechanical arm that can move a mass over a specified distance.	invention, prototype, structure, function, robotics	need staples, pins, scissors; copy student sheet	Proc: DI Proc: SI Proc: GI Proc: CS	3–4

Appendix B

Initial and Final Interview questions

Initial Interview questions	Final Interview Questions
1. Please describe your experience(s) in education from your training to your present position. a. What have been some ah-ha moments in your teaching experiences? b. What have you learned from your experiences? 2. How do you define inquiry-based instruction in the science classroom? a. What experiences/experts have helped develop this definition/description? b. Has it changed over time? 3. Do you have any questions or concerns about inquiry-based science instruction? a. When/How does it work best? b. When does it not work? 4. To what extent are you using the SEPUP units in your classroom? a. What is your opinion concerning the SEPUP curriculum? b. Are there concerns that others openly share? 5. To what extent do you believe your school and the district is implementing the SEPUP curriculum? a. What do you believe are possible barriers from full implementation at your school or at the district level? b. Do you have suggestions to overcome these barriers?	1. Please describe your experience(s) in education from your training to your present position. a. What have been some ah-ha moments in your teaching experiences? b. What have you learned from your experiences? 2. How do you define inquiry-based instruction in the science classroom? a. What experiences/experts have helped develop this definition/description? b. Has it changed over time? 3. Do you have any questions or concerns about inquiry-based science instruction? a. When/How does it work best? b. When does it not work? 4. To what extent are you using the SEPUP units in your classroom? What is your opinion concerning the SEPUP curriculum? **a. Have you had to adapt the SEPUP curriculum to fit your students and classroom and if so how?** **b. In your opinion, how well do the units align with the Standard Course of Study required by the state.** c. Are there concerns that others openly share? **d. When using any part of the SEPUP curriculum, can you describe the relative student engagement to the use of other methods?** 5. To what extent do you believe your school and the district is implementing the SEPUP

	curriculum? a. What do you believe are possible barriers from full implementation at your school or at the district level? b. Do you have suggestions to overcome these barriers? **c. How much teacher collaboration have you and your peers been involved in over the last year related to implementation of the SEPUP curriculum?**

Note: Bold text denotes changes made after analysis of the open-ended questions on the FI surveys.

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Appendix C

Interviewee Consent Form

I agree to participate as an interviewee in this research project, which concerns Determining Barriers to Implementation of Inquiry Based Science: A Mixed Methods Study of 6th-8th Grade Science Teachers in One Rural District. Over six months, this project will focus on determining barriers of implementation of a new science program and how those barriers may be overcome. I understand that my comments will be audio recorded and used for a dissertation research project to be conducted by Carol Moore and Dr. Krista Terry. The interview will take place in one session for 50-60 minutes. I understand that the only foreseeable risk could be feeling uncomfortable about answering some questions associated with my participation. I also know that this study may help add to the research regarding change and improvement in organizations.

I give Carol Moore ownership of the tapes and transcripts from the interview she conducts with me and understand that tapes and transcripts will be kept on her password protected laptop in her possession. I understand that information or quotations from transcriptions may be used in the publication of the dissertation using an alias name. I understand that I will receive no compensation for the interview.

I understand that the interview is voluntary and I can end it at any time without consequence. I also understand that if I have questions about this research project, I can call Dr. Krista Terry at *(828) 262-6052* or contact Appalachian State University's Office of Research Protections at (828) 262-7981 or irb@appstate.edu.

☐ I request that my name **not** be used in connection with tapes, transcripts, or publications resulting from this interview.

☐ I request that my name **be used** in connection with tapes, transcripts, or publications resulting from this interview.

______________________	______________________
Name of Interviewer (printed)	Name of Interviewee (printed)
______________________	______________________
Signature of Interviewer	Signature of Interviewee
______________________	
Date(s) of Interview (s)	

Vita

Carol L. Moore was born in Milwaukee, Wisconsin to James and Ruby Lefler. She graduated from North Stanly High School in North Carolina in June 1981. The follow autumn she entered Appalachian State University to study Elementary Education and in June 1985 was awarded the Bachelor of Science degree. In the fall of 1987, she began study toward a Master of Arts degree in middle school education and was awarded the M.A. in 1989. In the summer of 2011 Mrs. Moore began work toward her Ed. D. in Educational Leadership while also meeting the requirements of a Curriculum Specialist Licensure.

Mrs. Moore continues to be an active member of her professional organizations, the National Science Teachers Association, the NC Science Teachers Association, and the NC Science Leaders Association. She resides in Claremont, NC with her husband, Ted and has two children, Rachel and John.