ACHIEVING A COHERENT CURRICULUM IN SECOND GRADE: SCIENCE AS THE ORGANIZER

A Dissertation
presented to
the Faculty of the Graduate School
University of Missouri – Columbia

In Partial Fulfillment
of the Requirements for the Degree

Doctor of Philosophy

---

by

MEREDITH A. PARK ROGERS

Dr. Sandra K. Abell, Dissertation Supervisor

MAY 2006

The undersigned, appointed by the Dean of the Graduate School, have examined the dissertation entitled.

ACHIEVING A COHERENT CURRICULUM IN SECOND GRADE: SCIENCE AS THE ORGANIZER

Presented by Meredith A. Park Rogers

A candidate for the degree of Doctor of Philosophy.

And hereby certify that in their opinion it is worthy of acceptance.

Sandra K. Abell
Dissertation Supervisor

Paul Weaver

Lloyd H. Barrow

Jay Scribner

Judy Wedman

Dedicated to my grandparents, who taught me that to succeed you must believe in yourself.

ACKNOWLEDGEMENTS

I want to begin with thanking my doctoral advisor, Dr. Sandra Abell. Mere words cannot express my appreciation for your leadership. In my mind, you are a model mentor, demonstrating the fine art of knowing when to provide guidance and when to let me step out on my own. You have not only prepared me to be professionally successful with my research and teaching, but have engrained in me that being an educator means that I am forever a learner. As our relationship makes the transition from advisor/advisee to colleagues there is one thing I know will remain always constant – our friendship.

I also want to extend a thank you to my other committee members. Dr. Lloyd Barrow, thank you for your kind words of support throughout all of my studies. Your work with elementary teachers inspires me to keep my research grounded in the classrooms. Dr. Scribner, because of my work with Nudist/NVivo in your qualitative methods class I somehow became the resident expert of NVivo for science education. I am not sure if that is a good thing or a bad thing for the people I am helping. I have appreciated your mentorship in helping me gain experience in the research areas of program evaluation and qualitative research. Dr. Jan Weaver, thank you for opening your classroom door to me to conduct my first research project. Not only were the classes a good refresher of science content knowledge, but your interdisciplinary teaching team provided a model of professional collaboration that I hope to one day translate into my own practice. Dr. Judy Wedman, thank you for your support when I first arrived at MU. I had so many questions and aspirations when I started, and with your guidance I found the path I needed to help me obtain those goals.

Thank you to my family and friends for giving me the strength I needed to finish. More specifically, I want to thank my parents, Harold and Carol Park. Even though I am a long way from home, I could always feel their love and support. Whether it was an email, a phone call, or a surprise card in the mail, you always seemed to know just when I needed a pick-me up. Your love has always given me the courage I need to make my dreams come true. To my brother Steve and his family: my sister-in-law, Mary; my two nephews, Andrew and Alex; and my niece, Marisa, thank you for reminding me that regardless of how hectic things get it is important to make time to play. Last, I want to thank Aunt Alma, who always taught me to stand proud and with a little perseverance I can accomplish anything.

I am also fortunate to have an extensive support system of family and friends nearby. First, I want to thank my in-laws, the Todd, Rogers, Thomas, and Rupp families, for all their words of support and love for both me and Kevin. Secondly, to Colleen Bee, there is no better experience for two childhood friends to share than completing their PhDs. Thank you for your words of encouragement and for listening to every high and low moment along the way. To all my ARG buddies, thank you for the Friday nights of intellectual discussion, but more importantly for the much needed break and laughter.

I also want to thank Jill Bergee, Lisa Thompson, Tabitha Heath, Nicole Nichols, and JoNetta Weaver, the participants of this study. If not for their generosity and opening their classrooms to me there would not be a study. Their attitude and approach towards teaching elementary science is truly an inspiration I hope to pass on to all teachers I encounter.

Last, but certainly not least, I want to thank my husband Kevin, who in many ways has also earned this degree. I will forever be grateful for your patience and kindness during the past five years. Some may say that a PhD can be taxing on a new marriage, but your love has proven to me that we can survive any stress life may throw our way. As this chapter of our lives comes to an end, I look forward with anticipation towards our future.

TABLE OF CONTENTS

LIST OF TABLES

Table Page

LIST OF FIGURES

Figure Page

ACHIEVING A COHERENT CURRICULUM IN SECOND GRADE:

SCIENCE AS THE ORGANIZER

Meredith A. Park Rogers

Dr. Sandra K. Abell, Dissertation Supervisor

ABSTRACT

The purpose of this study was to examine how a team of four second grade teachers used their approach to teaching science as a means for designing and implementing a coherent curriculum. Within this study, curriculum coherency refers to making logical instructional connections that are both visible and explicit for students. A teacher using a common teaching strategy or critical thinking skills in such a way that the commonalities between subject areas are clearly demonstrated to students is one example of curriculum coherency.

The research framework guiding this study was phenomenology; I used a case study method for data analysis. The primary data source was field notes gathered during 10 weeks of classroom observations. Secondary data sources included observations of team meetings, two sets of interviews with each of the four teachers, an interview with the school principal, and artifacts used and developed by the teachers.

An analysis of the data led me to interpret the following findings: 1) the teachers viewed science as a tool to motivate their students to learn and believed in teaching science through an inquiry-based approach; 2) they described science inquiry as a process of thinking organized around questions, and saw their teaching role as shifting between

guided and open classroom inquiry; 3) they taught all subjects using an inquiry-based approach, emphasized the process skills associated with doing scientific inquiry, and consistently used the language of the process skills throughout their instruction of all disciplines; 4) their team's collaborative approach played a significant role in achieving their vision of a coherent curriculum; the successfulness of their collaboration relied on the unique contributions of each member and her commitment to professional development.

This study demonstrates how an inquiry-based science curriculum can provide educators with an effective model for designing and implementing a coherent curriculum. Furthermore, the findings have implications for elementary preservice and inservice programs with respect to using science teaching as a foundation for developing curriculum coherency.

CHAPTER ONE: INTRODUCTION

At the time of this study, U.S. K-12 education was focused on measuring accountability with respect to student, school, and district performance on standardized tests. The federal *No Child Left Behind Act* (NCLB) resulted in greater scrutiny of schools' annual yearly progress and increased standardized testing of all content areas and across multiple grade levels. Pringle and Carrier Martin (2005) believed that the emphasis on school accountability would make most districts realize the need for supporting elementary science for the purpose of ensuring long term student achievement in science. However, NCLB first focused on improving students' mathematic and literacy scores, with science not scheduled to be tested until 2007. This resulted in much of the time during the first five years of NCLB spent in elementary classrooms on test preparation for mathematics and literacy, and less time on teaching science and other subject areas.

Pringle and Carrier Martin (2005) found that many teachers were anxious about the already overcrowded school day and the pressure of meeting the daily requirements of "reading priority 2 ½ hours, math priority – 1 hour 15 minutes" (p. 354). From talking with teachers in my local school district, I learned that this time allotment was common in elementary classrooms. With nearly two-thirds of the school day devoted to just two subject areas, it is understandable that teachers would be challenged to fit in lessons for science and the other subject areas. In most cases, science takes a back seat to mathematics and literacy; thus, science is often considered a second-class core subject in the elementary curriculum (Roden, 2000).

The 2003 Trends in International Mathematics and Science Study (TIMSS) (Gonzales, et al., 2004) report painted a picture as to how poor performance in elementary science impacted global competitiveness. U.S. 4th and 8th grade students performed at an average level for both science and mathematics in comparison to the students in 46 other countries that participated in 2003. Although U.S. 4th grade mathematics performance did not change from 1995 to 2003, there was significant improvement in 8th grade mathematics. On the other hand, 4th grade science performance decreased slightly from 1995 to 2003, and 8th grade science scores improved only slightly over the 8-year period.

Considering the desire for the U.S. to be at the top in global production and competition, these “average” scores will not suffice. Researchers have taken notice and suggest that the unbalanced approach to teaching in the elementary curriculum may have some connection to students’ mediocre science performance (Raizen & Michelsohn, 1994; Roden, 2000; Sears, 2000).

As a former elementary teacher, I can sympathize with elementary teachers’ frustrations of wanting to make sure that students have the opportunity to learn all disciplines. However, the reality is that classroom teachers will teach what students need to know to be successful in this era of accountability. Soon K-6 educators will need to respond to science education issues because NCLB’s testing requirements will require them to be accountable for teaching science too.

As an educator, one way I tried to combat the pressure of teaching to the test while ensuring my students were prepared to succeed was to develop my curriculum from a coherent perspective. I was first introduced to the idea of curriculum coherency as an outdoor educator. Outdoor educators look across the various disciplines for commonalities, then group similar concepts or skills under an umbrella of a single theme or process skill. This theme or process is threaded throughout the curriculum. While this approach worked well when I was teaching a curriculum that was not textbook-driven or structured by a testing regiment, it was a different story once I entered the four walls of a classroom.

As a classroom teacher I needed to find a way to simultaneously meet the needs of my students and the standards-based curriculum. Although I could not teach exactly as I had when I was an outdoor educator, I did learn to adapt some of my previous teaching strategies for the classroom. For example, I took an interdisciplinary approach to designing my curriculum, which encouraged me to look across the disciplines for common learning outcomes. Using this strategy provided students with a more coherent approach to their learning.

Many elementary classroom teachers feel their time and resources are already stretched to their limits (Roden, 2000). In order to develop a balanced curriculum where science is also given priority we will need to find a way to help teachers meet the demands of an overloaded curriculum, unbalanced classroom schedules, and limited resources. It is this need that provided the rationale for this study.

Purpose of the Study and Research Questions

My primary research interest is to learn about ways to improve the state of science in elementary classrooms. Considering my own experiences with implementing a coherent curriculum, I believe there is a need to share the stories of other classroom teachers who are using some type of integrated approach to developing a curriculum of coherency.

When I first met a team of elementary teachers who used science to organize their curriculum, I knew their story needed to be told. As Crawford's study (2000) asserted, there is a need for more studies that focus on classroom implementation. My desire to improve the position of science in the elementary curriculum and Crawford's call for more classroom-based research about teachers' practice, are justifications for this study.

Thus, the purpose of this study was to examine how a team of second grade teachers taught science and how their approach to teaching science impacted their teaching of other subjects. Four research questions guided both the design and implementation of the study. These four research questions are:

1. How do these teachers view and teach science?
2. What role does science have in designing their curriculum?
3. How do they apply their approach for teaching science to their teaching of other subjects?
4. What is the role of team planning?

Conceptual Framework

Three key concepts frame this study. In the following section, I explain these concepts in relation to the context of this study.

Inquiry

Following the 1957 launch of the former Soviet Union's earth-orbiting satellite *Sputnik,* the U.S. government began to financially support the National Science Foundation's (NSF) initiatives for investigating ways to bring renewed vitality to school science programs (DeBoer, 1991). Joseph Schwab led the way in this reform in science education with his declaration for classroom inquiry. Schwab explained that "scientists no longer conceived science as stable truths to be verified; they were viewing it as principles for inquiry, conceptual structures revisable in response to new evidence" (in Bybee, 2000, p. 27). Therefore, "the constitutive components of scientific knowledge – principles, data, interpretations – as well as the constituted conclusions, must become the materials regularly taught and learned in science courses (Schwab, 1962, p. 65). However, Schwab's view of inquiry did not stop there. He also described enquiry[1] as a way of teaching classroom science. He asserted that "the teaching of science as enquiry" requires one to think of inquiry as both "a process of teaching and learning" (p. 65). He explained that,

> The complete enquiring classroom would have two aspects. On the one hand, its materials would exhibit science as enquiry. On the other hand, the student would be led to enquire into these materials. He would learn to identify their components parts, detect the relations among these parts, note the role played by each part, [and] detect some of the strengths and weaknesses of the enquiry under study. In short, the classroom would engage in an *enquiry into enquiry* [author's emphasis]. (p. 65)

By the late 1960s and early 1970s there was a wave of new science curricula that focused on Schwab's description of learning the process of science. These curricula, known as the "alphabet soup" (e.g., *Elementary Science Study* (ESS), *Science Curriculum Improvement Study* (SCIS), and *Science – A Process Approach* (SAPA)), stressed developing children's process skills. Schwab (1962) noted that science learning involves two parts – the teaching and learning of both the principles and process of science. Much of the focus in the era of the alphabet soup curricula was on the process skills of

[1] Schwab's choice of spelling for inquiry.

science and the principles of science were a side note. Unfortunately, it was this unbalanced approach to teaching science that eventually lead to the fall of these curricula (Atkin & Black, 2003).

This era came to an end in the early 1980s with the introduction of progressive educational goals. These goals focused on the notion of *scientific literacy* and included such themes as "Science-Technology-Society" (STS). This idea was formally introduced by James Gallagher in 1971, but like most things in education it took a while to surface (DeBoer, 1991).

> Gallagher argues that the new curriculum projects [of the alphabet era] took a limited view of science, focusing as they did on the conceptual schemes and the processes of science. Gallagher wanted learners to become familiar with the social interactions of science as well as with the structured disciplines themselves (De Boer, 1991, p. 178).

Advocates for an STS approach described a humanistic, value-oriented, and environmental application for the teaching and learning of science. The STS approach of the 1980s was concerned with offering students a cross-disciplinary approach to learning about everyday science so they could contribute to the well-being of society (DeBoer, 1991).

By the end of the decade, the scene had once again changed in science education. The influence of technology on society was gaining strength, especially in the fields of science and mathematics. In response, Rutherford and Ahlgren published the report *Science for All Americans* [*SFAA*] (1989). Several professional organizations began to prepare standards documents to bring a unified vision to the U.S. of what core content to teach in schools.

In science education, the American Association for the Advancement of Science [AAAS] (1993) published the *Benchmarks for Science Literacy* [*Benchmarks*] and the National Research Council [NRC] (1996) published the *National Science Education Standards* [*Standards*]. The basic foundation of the *Benchmarks* and the *Standards* returned to Schwab's idea of science as inquiry, but unlike the reform of the 1960s, the emphasis was on the concepts of science as well as the processes (NRC, 1996, 2000). The *Standards* identified teaching through inquiry as the foundation for reform.

> [Inquiry is] a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tool to gather, analyze, and interpret data; proposing answer, explanation, and predictions; and communicating the results. (NRC, 1996, p. 23)

For students to practice this kind of activity, teachers need to help students develop both understands about scientific inquiry and abilities necessary to do scientific inquiry (NRC, 1996, 2000). For this to occur, teachers also need to consider the essential features of classroom inquiry (NRC, 2000). These features are described as:

- Learners are engaged by scientifically oriented questions.
- Learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions.
- Learners formulate explanations from evidence to address scientifically oriented questions.
- Learners evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding.
- Learners communicate and justify their proposed explanations. (NRC, 2000, p. 25)

Within the context of this study, the essential features of classroom inquiry and the processes of scientific inquiry guide my view of how to design inquiry-based science instruction.

Curriculum Coherency

Instructional approaches that include elements of curricular integration have gained support from the field of cognitive science. Researchers suggest that teaching needs to focus on the whole curriculum, rather than through individual or fragmented ideas in order for students to learn (Caine & Caine, 1993; Gaff, 1993). Coherent instruction encourages connections among concepts and ultimately helps learners construct a stronger schema of knowledge. Learners who can reflect on and make connections via an integrated experience are able to build a more complex understanding of a phenomenon.

The elementary science curricula of the 1960s and early 1970s described science as a means for connecting the curriculum (Atkin & Black, 2003). As time progressed however, less emphasis was given to designing a connected curriculum within the boundaries of the core disciplines; instead a "transdisciplinary approach" (Drake, 1993) to teaching science was employed. The STS theme of the 1980s is an example of this trend; the focus was to transcend the boundaries of traditional disciplines and approach science from blended view of the sciences (e.g., environmental science).

In the 1990s, following the publication of *SFAA* (Rutherford & Ahlgren, 1989), AAAS launched the reform initiative "Project 2061". One recommendation for curricular reform described in *SFAA*, as well as its companion book the *Benchmarks* (AAAS, 1993), is the use of a thematic approach that connects science, mathematics, and technology with each other as well as other disciplines. The writers of the *Benchmarks* explained,

> With regard to curriculum there are three senses in which Project 2061 is solidly behind integration. First, integrating planning – the curriculum in science, mathematics, and technology (and perhaps more) should be the

> result of the collaboration of teachers from all the relevant subject and all grade levels, not a parceling out to grade and subject specialists. Second, interconnected knowledge – the students' experiences should be designed to help them see the relationships among science, mathematics, technology and between them and other human endeavors. Third, coherence – the students' experiences need to add up to more than a collection of miscellaneous topics. (AAAS, 1993, p. 320)

A few key phrases stand out with respect to the conceptual framework of this study: collaboration of teachers, relationships, and coherency. Beane (1995) explained that when one moves toward a coherent curriculum parts are connected for the purpose of a larger goal and these connections need to be made explicit to the learner. For the purpose of this study, the idea that parts of disciplines need to be connected in explicit ways guided my understanding of a designing a coherent curriculum.

Professional Collaboration

The third piece of the conceptual framework for this study is professional collaboration. Using a case study approach afforded me the opportunity to look at the organization of a teaching team. I examined how they interacted with one another, what they contributed to their teaching community, and how their collaborative approach to planning impacted their teaching. Wenger's (1998) notion of *communities of practice* helped to guide my concept of professional collaboration.

The term "community of practice" (CoP) is grounded in social learning theory and includes three key components "First, communities of practice mutually engage on the task at hand. Second, they communally negotiate the contours and focus of their joint enterprise. Third, they develop a set of shared repertoires to effectively address their work" (Supovitz, 2002, p. 1598). Regardless of the amount of experience contained in a

CoP, these three components constantly are being refined and honed because each new situation presents new challenges.

According to Wenger (1998), CoPs are everywhere - at work, school, home, and society. Throughout our daily lives we move in and out of various communities that follow specific practices. These CoPs provide the "ideal situated contexts through which implicit and explicit meanings are appropriated and negotiated by members of the community" (Hung, Chee, Hedberg, & Seng, 2005, p. 160). The social networks of a CoP "[form] naturally and are informally bound by the work that people engage in together; they are self-organized, and memberships are based on participation rather than on official status" (Wenger cited in Foulger, 2005, p. 3). When needed, meanings are negotiated among members based on the assumed understandings of the culture. Therefore, within the structure of a CoP, knowledge is constructed according to the group's explicit and tacit understandings.

The purpose of examining the CoP of a team of teachers was to understand the role of participation and how collaboration impacted their teaching. Wenger (1998) noted that participation is not solely defined by how one engages in the community, but also by how one's identity is constructed in relation to the community. In this case, I focused on the relationships within the community to learn how teammates viewed each other's participation.

Significance of the Study

Researchers in science education have called for further investigations into several topics. First, there is a need for studies that examine classroom teachers' use of inquiry teaching practices (Crawford, 2000). Second, given the concern that elementary science does not receive the attention needed in the classroom led researchers to recommend studies of different approaches to teaching elementary science (Raizen & Michelsohn, 1994; Roden, 2000; Tilgner, 1990). Third, Pang and Good (2000) claimed "there is a need to identify and explore the challenges in implementing integrated curricula, ways teachers effectively deal with various constraints at different school levels, and implications for teacher empowerment" (p. 77). This study responds to these calls by examining a team that 1) was comprised of experienced elementary teachers, 2) regularly taught science, and 3) used science as a means for developing an integrated coherent curriculum. The findings from this study have the potential to play a significant role in furthering our understanding of achieving a coherent elementary curriculum with science as the organizer.

Organization of the Dissertation

This study is divided into six chapters. Chapter One provided a brief overview of research including the rationale, purpose, research questions, and significance of the study. In addition, I presented the conceptual framework that guided the study. The features of the conceptual framework include inquiry-based teaching, curriculum coherency, and professional collaboration. Chapter Two elaborates on these three concepts by delineating how they are discussed within the research literature.

Chapter Three outlines the research approach to this qualitative study. This includes a description of the guiding research tradition and the design of the study. In addition, I include details about the context of the study including the school environment, the curriculum, and the participants. I also describe data collection strategies and analysis methods. The chapter ends with a brief discussion on the trustworthiness of the findings as a function of the research design and tradition.

Chapters Four and Five detail the findings of the study. The purpose of Chapter Four is to set the stage for the assertions laid out in Chapter Five. Chapter Four consists of four vignettes of classroom teaching and collaboration in action and provides the reader with a window into the case.

Chapter Five details the assertions that emerged based on the analysis of the data. The four research questions organize these findings. Throughout this chapter, I refer to the vignettes in Chapter Four, as well as interview data, as evidence to support the assertions.

Chapter Six is the final chapter. This chapter includes a brief discussion of the findings in relation to the research literature. This chapter concludes with implications for practice and recommendations for future research.

CHAPTER TWO: LITERATURE REVIEW

This chapter is organized around four main topics that further elaborate and complement the conceptual framework guiding this study. The four topics include: a) inquiry as an approach to teaching science and the use of a learning cycle approach to inquiry-based instruction, b) elementary teachers' views and practices of teaching science, c) connecting science with other subject areas for the purpose of developing a coherent curriculum, and d) the nature of professional collaborations in educational settings. The chapter concludes with a description of the gaps found in the research literature that this study will help to address.

Science as Inquiry

As part of his 1961 Inglis Lecture at Harvard University, Joseph Schwab explained that scientists no longer viewed scientific knowledge as truths examined for the purpose of verification "but as principles of enquiry – conceptual structures – which could be revised when necessary" (Schwab, 1962, p. 11). To further elaborate on this comment, Schwab described the difference between *stable* and *fluid* enquiry (1960, 1962). He explained that some scientists follow a path of stable enquiry when they know that terms of their investigation may be "tentative… and [should be] tested [to] determine how and where they fail[ed] in the course, [but they] are not permitted to divert from [their] interest in the subject-of-enquiry taken as subject-in-fact and from [their] hope of positive conclusions about it" (1960, p. 20).

With the end of World War II and the launch of Sputnik many scientists were beginning to move towards a more fluid view of science enquiry, meaning "after the invention and pretest of terms through debate, there must be extended test of the principle by practice" (1960, p. 20). Therefore the goal of fluid enquiry, unlike stable enquiry, was for scientists to discover and repair the inconsistencies or limitations that they found in their research. This extension of testing in fluid enquiry "involves the pursuit of data and the formulation of conclusions as do researchers of the stable sort, but experiments are performed, date deduced and interpretations tried in order to test the terms in which the enquiry is pursued" (1960, p. 20). Schwab's comments from this lecture turned out to be a turning point for how curriculum designers and policy makers thought of science teaching. Schwab argued the need for an approach to science teaching that was more representative of the changing conception of science itself (DeBoer, 1991).

Schwab's (1962) bold challenge for change in classroom science was that teachers needed to represent science learning as an "enquiry into enquiry" (p. 65). For this to occur, there needed to be extensive reconsideration of both the students' and the classroom teacher's role in the process of classroom inquiry. Schwab (1962) explained that a process of learning through inquiry should mean

> relinquishment of habits of passivity, docile learning, and dependence on teacher and textbook, in favor of an active learning in which lecture and textbook are challenged. The lecture and textbook cease to be authoritative sources of information to be learned and become materials to be dissected, analyzed. (p. 66)

To assist with this task of looking at science with a critical eye Schwab (1960, 1962) suggested that students read and analyze real pieces of scientific research (e.g., a report of a study in a journal); when doing so they should examine not only the content but the process of how the science was carried out (DeBoer, 1991).

As for the teacher's role in an inquiry classroom, Schwab stated first and foremost it is the teacher's responsibility to assist students with understanding the parts of an inquiry. For example, students should not be expected "to know what to look for in a report of scientific enquiry [or] what questions to ask of the material" (Schwab, 1962, p. 67). Instead, the teacher takes on the role of a facilitator of inquiry, helping students understand how to inquire, rather than a purveyor of knowledge.

Heeding Schwab's suggestions for change in the teaching and learning of classroom science, the developers of new curriculum projects of the 1960s and 1970s highlighted the teacher as a facilitator and emphasized science process and process skills. Furthermore, the Science Curriculum Improvement Study (SCIS) introduced the learning cycle as an approach for designing and implementing inquiry-based elementary science teaching (DeBoer, 1991).

Science as Inquiry: The Learning Cycle Approach

Schwab's vision of a fluid approach to inquiry closely resembled Robert Karplus' teaching approach called the "learning cycle," which he and colleagues used to develop the Science Curriculum Improvement Study (SCIS) (DeBoer, 1991). Karplus' view of a learning cycle included opportunities for students to first explore and gather data, then analyze the data to interpret their results and invent plausible explanations through discussions with their peers and teacher, and finally extend their understanding of these explanations with further investigations.

A learning cycle approach to teaching science gained support in the field of science education because of its basic constructivist foundation. During this time period the ideas of constructivists like Jerome Bruner and Jean Piaget were influencing much of educational reform. The original three phases of the learning cycle, "exploration, concept introduction, and concept application" (Karplus, 1977, p. 173) mirrored Jean

Piaget's process of "mental functioning" (Renner, Abraham, & Birnie, 1988, p. 39). Renner and Abraham (1986) explained that,

> At the heart of the Piagetian developmental model lies the concept of mental structures which have been called "systems of transformation" (Piaget, 1970)… The process starts with mental assimilating, which results in disequilibration, which causes the mental structures to accommodate to the assimilation and end up as changed mental structures. (p. 122)

Piaget's view of mental constructs also provided a foundation for the more current research on conceptual change.

Teachers' Views of the Learning Cycle Approach

Even though inquiry-based constructivist approaches are touted in the standards as *the* way to teach science, some researchers have found that teachers do not necessarily agree. For example, Czerniak and Lumpe (1996) found that, of the 168 K-12 teachers they surveyed, 81% did not believe it was "necessary to use constructivist strategies in their science classroom to be an effective science teacher, and 74% reported using constructivist strategies less than once a week or never" (p. 259).

Jones, Carter, and Rua (1999) noted that many of the teachers in their study had similar views prior to participating in a graduate level teacher education course. However, their views changed once they experienced a learning cycle process for themselves as both learners and teachers. To illustrate this point Jones et al. (1999) explained,

> Using a constructivist approach initially became intelligible to the teachers as they worked through learning cycles to gain understanding of science concepts and then as they shaped a meaningful representation of constructivism through their own science teaching. Using a constructivist approach became plausible as changes in students' understanding showed the teachers that different ways of teaching science may be more useful in

> promoting conceptual growth than the worksheets and note-taking that have been traditionally used. (p. 555)

Based on these two studies there is evidence that teachers do not view nor practice science as inquiry. There is some indication however, that if teachers are given the opportunity to experience science as inquiry for themselves through a learning cycle approach, they will be more likely to try and implement it into their own teaching practice.

Research on the Effectiveness of a Learning Cycle Approach

A few studies have looked at teachers' use of a learning cycle approach with regards to student learning. In particular, Abraham and Renner (1986) and Renner, Abraham, and Birnie (1988) examined the use of the learning cycle in high school science chemistry (1986) and physics (1988). The purpose of the chemistry study was to determine if using a learning cycle approach was a more effective approach for teaching science than a traditional method. They designed their study to answer this question by asking if the sequence of the three phases is important to students learning the concepts; the purpose of the physics study was to examine the necessity of all three phases in the learning cycle.

Abraham and Renner (1986) identified a traditional method to teaching science as one where the "invention" phase or the middle phase of the cycle, comes first in the sequence. Students are given the information and terms first and then they explore the phenomenon for the purpose of proving the explanation to be true. On the other hand, the chemistry classes that followed a learning cycle approach ensured the invention phase came after some kind of experience with the phenomenon. Based on students' comments and their test results, Abraham and Renner concluded “that [indeed] the sequence of the learning cycles is important… it is the position of the invention phase that is important to optimum learning” (p. 141).

Based on the results in the physics study, Renner, Abraham and Birnie (1988) asserted:

> 1. Providing just materials and directions for students and allowing them to explore is not *efficient* in learning concepts. That conclusion leads us to have serious doubts regarding the “free exploration” environment, if the purpose of such an environment is to learn the content and structure of science.
>
> 2. Thoroughly explaining a concept before providing experiences with materials results in little or no conceptual understanding. That conclusion casts serious doubts upon the teacher-centered exposition teaching procedure and the thorough explanations provided by textbooks.
>
> 3. Explorations which produce data need to be followed by discussions – conceptual inventions.
>
> 4. All phases of the learning cycle are necessary, but there can be specific conditions when one or more phases can be substituted for.
>
> 5. Students believe that all phases are necessary. (Renner et al., 1988, p. 56)

From a slightly different perspective, Musheno and Lawson (1999) looked at the use of a learning cycle approach with science text and its impact on student learning. They found that if students read about a concept in context before given the explanation of the concept, they scored higher on information processing for reasoning. This finding complements Renner et al.’s (1988) second assertion (see above), as it suggests the need for textbooks to also follow a learning cycle approach. Musheno and Lawson (1999) claimed that it is necessary for textbooks to be organized using a learning cycle format so students have the opportunity to read about the concept in an application context first before reading about the theory behind the concept.

Regardless of these claims about the effectiveness of using a learning cycle approach, Settlage (2000) noted that the learning cycle is still an underutilized method in science teaching. He questioned if one reason why teachers have difficulties understanding how to implement the learning cycle into their own classroom teaching is because it is different from how they learned science. In an attempt to answer this question, Settlage (2000) designed a study that explored factors influencing preservice teachers' capability for understanding the learning cycle. Settlage found that "teacher educators cannot predict an education major's potential for understanding the learning cycle on the basis of the preservice teacher's perception of his or her ability to teach science" (p. 48). However, "significant correlations were found between understandings of the learning cycle and posttest measures of self-efficacy…[suggesting] that comprehending the learning cycle serves as a mechanism for advancing the science teaching efficacy of future teachers" (p. 49).

Summary

In the early 1960s Schwab discussed the idea that school science should be taught in a manner similar to how scientists do science. This included looking at science through a lens of inquiry, meaning viewing science as a set of principles to be studied and a way of teaching. He claimed that inquiry should be the preferred method for teaching science because it mirrors how scientists practice science. Classrooms need to prepare students to think about how to do science as well as the content of science.

The learning cycle approach for teaching science as inquiry was developed shortly after Schwab advised the need for change; it was integrated into the elementary SCIS program. A learning cycle approach to science follows Piaget's ideas of mental functioning, and includes many principles of constructivism. The learning cycle consists of three phases with evidence pointing to the need for the invention or explanation phase to come after initial exploration with the concept.

Researchers claim that teachers have difficulty implementing constructivist approaches like a learning cycle for several reasons: 1) they do not feel it is necessary, 2) they have not experienced the approach in their own learning so they do not know how to use it, or 3) they simply do not understand the differences between the phases and importance of the sequence. Although most of the research has focused on instruction using a learning cycle approach, one study also discussed the use of a learning cycle approach in organizing textbooks.

Elementary Teachers' Views and Teaching of Science

Across the literature there is a common theme of a lack of science in elementary classrooms (Earl & Winkeljohn, 1977; Moore & Blankenship, 1977; Raizen & Michelsohn, 1994) because literacy and mathematics are viewed more important in the elementary curriculum (Collins, 1997; Raizen & Michelsohn, 1994; Roden, 2000).

During the late 1980s and early 1990s, there were several summaries of research published about teacher beliefs (Nespor, 1987; Kagan, 1992; Pajares, 1992). Since that time there has been a significant number of studies published on teachers' beliefs about science teaching and learning, such as: Abell and Roth (1992); Beck, Czerniak, and Lumpe (2000); Bryan (2003); Fetters, Czerniak, Fish, and Shawberry (2002); Czerniak and Lumpe (1996); Laplante (1997); Levitt (2001); and Tobin, Briscoe, and Holman (1990). Because the present study focuses on experienced elementary teachers, I selected to review studies that discussed practicing elementary teachers' views and practice of teaching science.

With this narrowing of the research I found two recurring themes: 1) external constraints teachers face inhibit them putting their reform-based beliefs about inquiry science into practice (Abell & Roth, 1992; Beck et al., 2000), 2) personal constraints such as a lack of vision or their own traditional science experiences hinder elementary teachers from implementing inquiry-based practices in their science teaching (Bryan 2003; Fetters et al., 2002; Laplante, 1997; Levitt 2001; Tobin et al., 1990). I elaborate on these themes in the following two sections.

Teachers' Views of External Constraints on Inquiry-based Practice

Beck et al. (2000) studied teacher beliefs of constructivist practices. This study is important in understanding teachers' beliefs about inquiry-based teaching because of the constructivist nature of scientific inquiry as a teaching approach. Beck et al.'s research identified factors that influenced K-12 science teachers' implementation of constructivism in their classroom. The majority of the teachers (42%) that responded to their five survey series were elementary teachers (K-4). They first examined teachers' views of these kinds of practices and then asked the teachers about the implementation of the constructivist practices.

Beck et al. surveyed teachers about five key aspects of constructivist teaching in relation to their science teaching (one aspect per survey). These aspects included personal relevance, scientific uncertainty, critical voice, shared control, and student negotiation. Table 1 summarizes Beck et al.'s findings on each of these constructivist aspects of teaching science. Included in the table are the five constructivist aspects teachers were surveyed about, their beliefs about teaching each of the aspects, and a list of constraints or concerns the teachers believed may have affected their implementation of the aspect.

The teachers recognized the importance of using a constructivist approach to teach. They explained that factors such as a lack of planning time, money, and resources may constrain them from doing so. In addition, a few of the constructivist aspects worried the teachers because of classroom management issues. The findings from this study implied that although these teachers understood the desire to teach science from a constructivist perspective such as inquiry, they were not necessarily ready to transform their beliefs into practice.

In Abell and Roth's case study (1992) of a prospective elementary teacher, Marie expressed a desire to teach elementary science, an unusual desire in preservice elementary teachers. Although Marie's formal science background experience in her teacher preparation program was similar to her peers' (three biology courses, two of which were for elementary majors, one physics course for elementary majors, and one geoscience course also designed for elementary majors), her experience in a geoscience course changed her opinion of science and motivated her to become more involved in science programs in local elementary schools. In addition to motivating Marie, the geoscience course also increased her self-confidence to teach science, which Luera and Otto (2005) reported is unlike most elementary teachers' experiences with undergraduate science.

Table 1

Summary of Teachers' Beliefs and Implementation of Constructivist Science Teaching

Constructivist Aspect	Teachers' believed teaching …	Concerns/Constraints to Implementing a Constructivist View
Personal Relevance	For personal relevance in the classroom can motivate students increase student interest and involved students in their own learning. (p. 334)	• Amount of time it takes to prepare for and to teach for personal relevance. • Covering less content • Unsure if necessary external factors (e.g., materials, money, supplies) will be supplied.
Scientific Uncertainty	Scientific uncertainty in the classroom can help students understand the limitations and imperfections in science and that science changes over time. (p. 335)	• Amount of time it takes to prepare for and to teach for scientific uncertainty. • Classroom management issues. • Unsure if necessary external factors (e.g., materials, money, supplies) will be supplied.
Critical Voice	Critical voice in the classroom can help students take responsibility for and get involved in their own learning. (p. 336)	• Lack of collegial and administrative support to address this aspect. • Time to plan. • Assessment strategies that assess for this aspect. • Students' misuse.
Shared Control	For shared control in the classroom can help students take a vested interest in and ownership of their learning. (p. 336)	• Concerned about the immaturity and inexperience of their students in implementing this aspect. • Unsure if necessary external factors (e.g., materials, money, supplies) will be supplied.
Student Negotiation	Student negotiation in the classroom can help students work in group situation, improve communication and higher-order thinking skills, and increase student interest in science. (p. 337)	• Concerned about classroom management. • Unsure if necessary external factors (e.g., materials, money, supplies) will be supplied.

Note: Developed from the findings described in Beck, Czerniak, and Lumpe (2000).

Abell and Roth (1992) identified Marie as a science enthusiast. They explained that Marie's views about science teaching and learning involved "a 'hands-on' approach as a way to motivate and actively involve students, and she thought that science was for all students, not just the brightest" (p. 587). During Marie's student teaching, the researchers noticed that her view of science teaching and learning also demonstrated the importance of science processes.

The researchers found that, regardless of Marie's enthusiastic view of elementary science, constraints inhibited her from implementing her views in her teaching. Like many experienced elementary school teachers, Marie encountered limiting factors such as time, facilities, equipment, and background knowledge that significantly hindered her use of inquiry-based science practices (Abell, 1990; Beck et al., 2000; Tilgner, 1990; Young & Kellogg, 1993). However, Marie also faced slightly different constraints because she was trying to implement these visions during her student teaching experience. Abell and Roth (1992) explained that Marie's position as a student teacher created additional constraints for her such as "expectations of her cooperating teacher, her university supervisor, and the other fourth grade teachers. Their perceived resistance to strategies such as group work and their perceived insistence on accountability via worksheets and tests led Marie to question and, at times, adapt her teaching" (p. 591) to fit their expectations more.

Teachers' Views of Personal Constraints on Inquiry-based Practice

Many elementary teachers rely on district-provided science curricula to guide their science teaching. They do not feel comfortable or confident enough in their own abilities to plan and teach science from an inquiry-based perspective (Bryan, 2003;

Fetters et al. 2002). As Tobin et al. (1990) explained, even if a teacher shows a commitment to change his/her science teaching from a traditional to an inquiry-based approach, it does not necessarily mean s/he has a vision of what that ought to look like. Moreover, if a teacher develops a vision for reform-based science teaching, s/he may not be able to personalize the vision in order to successfully implement it in the classroom.

Tobin et al. (1990) studied how one elementary teacher's determination to teach science and mathematics with a more reform-minded approach helped her to overcome the constraints imposed by an inappropriate curriculum. This teacher attributed her successes to achieving her vision of science teaching because of the support she received from parents, school administrators, colleagues within the school, and at a later time, personnel with district and state educational agencies (Tobin et al., 1990). However, as Raizen and Michelsohn (1994) noted, this amount of support is not the norm for elementary science teaching.

Similar to Tobin et al (1990), Levitt (2001) explained that even though "teachers [may] adopt individual pieces of the standards, they may not yet embrace the whole vision" (p. 19). Levitt's study examined 16 elementary teachers from two school districts who were participating in a local systemic initiative for science education reform. Overall, Levitt found varying gaps between the teachers' beliefs and the principles of reform, suggesting as did Tobin et al. that elementary teachers were beginning to move towards a reform-minded orientation of teaching science, but they required support with transforming these beliefs into practice.

Fetters et al. (2002) examined teachers' views of science within an inquiry-based professional development program. They noted that when the teachers were immersed in reform-based inquiry science activities and curricula, they became anxious. Fetters et al. explained that the teachers had never experienced learning science from an inquiry perspective for themselves and in turn they were not confident in their ability to teach science in this way to their own students. Fetters et al. discussed the need for professional development to help practicing teachers redefine their roles as both learners and teachers of inquiry-based science for only then would they feel successful in implementing a reform-based curriculum of science as inquiry.

Fetters et al. (2002) found the elementary teachers in their study had similar views to the two teachers Laplante (1997) studied. Laplante studied two 1st grade teachers who taught science in a French-immersion program. He found that the teachers viewed themselves as consumers of knowledge because of their own experiences with science as students. The teachers relayed this image to their students. Laplante explained that the teachers in his study "Put scientists on a pedestal and consider them to be gifted with cognitive abilities they and their students do not possess. They view science more as a body of knowledge than as a process of inquiry" (p. 290). The issue of language development because of the students' ages and the fact that it was a French-immersion school was recognized possible external constraints for these teachers to overcome. However, Laplante found that students' limited language abilities were not as constraining as the teachers' *nested epistemology* of teaching science as a body of knowledge to be consumed rather than inquired about.

Findings from Bryan's (2003) case study of Barbara, a prospective elementary teacher also incorporated the notion of nested beliefs. Bryan described two nests of beliefs which lied on opposite ends of a continuum. At one end, nest A of Barbara's beliefs described her practice of science teaching. Meanwhile, nest B located on the other end of the continuum, included characteristics of Barbara's vision of how she wanted to teach science. Bryan found that Barbara's foundational beliefs about control and the goal of science instruction (that concepts in science are truths and goal of instruction is for students to know these truths) tended to direct her "toward a didactic, teacher-centered orientation to teaching science" (p. 857). Therefore, Bryan learned that for the most part Barbara described teaching from an inquiry perspective, but practiced more of a traditional view.

King, Shumow, and Lietz (2001) reported a similar finding in their study of urban elementary school teachers. They explained, "There was a disconnection between what the teachers said they did (or are trying to do) vs. what observers saw them doing in the classroom" (p. 106). This finding appeared to be a theme across the literature – teachers described their view of teaching science as inquiry-based (e.g., using words like facilitate and hands-on), but when it came to teaching science they could not transfer their views into practice.

Summary

Both external and personal constraints were found to be barriers to elementary teachers in implementing constructivist, inquiry-based approaches to teaching science. From this review of the research on elementary teachers' beliefs about science teaching, I realized it is not external constraints but a limited understanding of how to transition from a didactic to a constructivist science teaching approach that hinders elementary teachers from using an inquiry-based approach. This limited understanding comes from the teachers' own lack of personal experience and knowledge of science as inquiry.

Connecting Science to Other Subject Areas

Reform Calls for a Connected Curriculum

In the publication of *Science for All Americans* (*SFAA*) (1990) Rutherford and Ahlgren described curricular connections as an important component of the vision for scientific literacy for all Americans. Science literacy was defined as "the knowledge and habits of mind that people need if they are to live interesting, responsible, and productive lives in a culture in which science, mathematics, and technology are central" (AAAS, 1993, p. 322). AAAS's Project 2061 initiative responded to *SFAA*'s vision for science literacy with the publication of supporting documents (e.g., *Benchmarks for Science Literacy* [*Benchmarks*] (1993) and *Blueprints for Reform: Project 2061* (1998)). Within these supporting documents the notion of connecting science with other disciplines was repeatedly discussed.

Besides AAAS, professional organizations[2] related to each content area have developed curriculum guidelines recommending curricular connections in order to develop more scientifically, mathematically and civically literate learners (Ford, Yore, & Anthony, 1997). Although these policy documents may view the core commonalities among the various content areas through slightly different lenses, when they are examined through the generalist lens of an elementary school classroom teacher, the central features include: language acquisition, critical thinking, habits-of-mind, importance of student ideas, concrete (hands-on) experience, scaffolded learning, and

---

[2] Refer to the following curriculum standards documents for further information on how each organization describes the need for interdisciplinary links and real-world connections across the content areas: *National Council for the Teaching of Mathematics, 2000; National Science Education Standards, 1996; National Council for the Social Studies, 1994;* and the *International Reading Association* and *National Council of Teacher of English, 1996.*

content integrity (Yore, Shymansky, & Anderson, 2005). Therefore, the standards in all content areas suggest the need for curriculum to be viewed through multiple disciplinary lenses rather than a single lens.

Although designing a connected curriculum is not a new idea, it has been neither fully rejected nor accepted by researchers and practitioners as a viable means of delivering an overloaded curriculum. Factors such as time, money, professional support, and a lack of consensus on the best way to develop a connected curriculum are just a few of the obstacles educators have to hurdle. Regardless of these problems, researchers and curriculum developers do agree that there is a need for a curricular model that allows teachers and students to meet the demand of an already congested curriculum (Beane, 1995; Boyer, 1995b; Fogarty, 1993; Jacobs, 1989; Vars & Beane, 2000). The main concern is that few teachers are informed as to how to design an effective connected curriculum. This concern was highlighted in the following *Standards* description for program development.

> Science content must be embedded in a variety of curriculum patterns that are developmentally appropriate, interesting, and relevant to students' lives…. [Therefore], if teachers are to teach for understanding as described in the content standards, then coverage of great amounts of trivial, unconnected information must be eliminated from the curriculum. Integrated and thematic approaches to curriculum can be powerful; however they require skill and understanding in their design and implementation. (NRC, 1996, p. 6)

In 1993 Kirst, Anhalt, and Marine (1997) interviewed a group of people representing a variety of different education levels (K-16), national organization and union members, politicians, and policy makers. The objective of their study was to examine the political issues that may arise because of *SFAA*'s vision of scientific literacy by the year 2061 (commonly referred to as Project 2061). When the researchers asked specifically for comments about the integration of science with mathematics, technology, and social studies, they received mixed feelings from the interviewees. With regards to mathematics, all respondents supported the idea of curricular connections between science and mathematics; however they voiced concerns about the idea of integration not aligning with college entrance exams or text book. Because there is a tension in some mathematics education communities about how to best approach the teaching of certain mathematics concepts, integration would probably not be supported in highly compartmentalized environments. Some leaders in the field of mathematics felt that the *Benchmarks* left out important mathematical concepts that do not mesh well with integration (Kirst et al., 1997).

Project 2061 also included goals for integrating science with technology and with social studies. Some educators felt that the social sciences were at the bottom of the integration list for fulfilling the vision of *SFAA* (Kirst et al., 1997). The representatives from the social sciences that Kirst et al. interviewed believed the *Benchmarks* had great potential for helping to get more time into the elementary classroom for science and social science, but they felt that it was not happening. It was their opinion that the integration of the two sciences would not receive the same level of recognition in the reform movement as integrating science with mathematics and technology (Kirst et al.)

Kirst et al.'s study raises awareness about the difficulty of implementing a connected approach to curriculum design. It is critical for all stakeholders of all content areas to be on board with the idea, and until this happens achieving the science standards will continue to have an uphill battle.

Defining a Connected Curriculum – Towards Coherency

Although content specific organizations (e.g., NRC, NCTM, NCSS, and IRA/NCTE) emphasize curricular connections within their reform and standards documents, there are curriculum development associations, such as the Association for Supervision and Curriculum Development (ASCD) that focus their attention on the idea of how to design a connected curriculum. For example, James Beane edited the 1995 ASCD Yearbook addressing the idea of moving towards a coherent curriculum. He defined curriculum coherency as,

> [Having] a sense of the forest as well as the trees, a sense of unity and connectedness, of relevance and pertinence. Parts or pieces are connected or integrated in ways that are visible and explicit. There is a sense of a larger, compelling purpose, and actions are tied to that purpose. (p. 3)

There are various labels given to the idea of curriculum coherency such as integration, interdisciplinary, thematic, and core curriculum to name a few. This shows a debate among researchers about the language of curriculum coherency. Jacobs (1989) stated that if researchers cannot agree upon what to call a coherent curriculum, then it is no surprise to learn that classroom teachers are having the same problem. This debate causes confusion when trying to plan a coherent curriculum.

For example, Jacobs herself preferred to use the term *interdisciplinary*. She defined this approach as, "A knowledge view and curriculum approach that consciously applies methodology and language from more than one discipline to examine a central theme, issue, problem, topic or experience" (p. 8). From a slightly different perspective however, Grady's writings (1994) indicated an interdisciplinary approach as one that would help students gain the necessary content knowledge, but would also support the development of their basic learning skills. These skills included: using language productively; thinking about various solutions to a problem and then designing an investigation to determine the most logical solution; understanding scientific and technological ideas and using appropriate tools from these fields; using creativity and imagination; understanding group dynamics and team collaboration; and developing independent learning skills to assist you in furthering your own learning.

Another definition for interdisciplinary curriculum stems from the idea of developing skills, but refers to the development of common skills used across the disciplines (Drake, 1993; Drake & Burns, 2004). Skills commonly used across the various disciplines include literacy, collaborative learning, storytelling, thinking skills, numeracy, global education, and research skills. Drake (1993) noted that "given today's educational technologies and the emphasis on metacognition, most [teachers] turn to critical thinking skills as the organizing principle for order and structure" (p. 38). With an interdisciplinary-skills approach "the content and procedures of individual disciplines are transcended; for example, decision-making and problem solving involve the same principles regardless of discipline. This makes intuitive sense to teachers" (p. 38). By using an interdisciplinary approach, greater emphasis is placed on metacognition which demonstrates to students that learning higher-order thinking skills is critical to all disciplines and is something that supports their learning outside of the classroom as well.

With so many interpretations of the term interdisciplinary, it is understandable why teachers have different perceptions about the term and why it causes problems when trying to plan a curriculum. Jacobs (1989) illustrated this point with the following scenario:

> Sometimes I have heard teachers refer to their "interdisciplinary unit" when, in fact, their meaning of interdisciplinary unit is 180 degrees different from their colleagues' down the hall. It is essential that there be some fundamental agreement of the meanings of the words that will be used to describe the plan that emerges from the design efforts or there can be real confusion. (p. 6)

Therefore, in an attempt to reduce the confusion about the terminology used in this study, I scoured the literature for the terms mostly commonly referred to when discussing a connected curricular approach. Besides coherent curriculum and interdisciplinary, three other terms are frequently mentioned in the literature. These are: core curriculum (Vars, 1993), thematic instruction (Dickinson & Young, 1998), and integrated curriculum (Drake, 1993; Huntley 1998).

Vars referred to a core-based curriculum as the "Needs, problems, and concerns of a particular group of students are identified and skills and subject matter from any pertinent subject are brought in to help students deal with those matters" (p. 92). On the other hand, a thematic form of instruction is characterized by an overarching topic (e.g., ocean) that is used to create relationships between domains (Stoddart, Pinal, Latzke, & Canaday, 2002). An integrated curriculum emphasizes a balance on each domain to the point that a synergistic relationship is developed across domains so that they complement and reinforce one another (Huntley, 1998). Drake (1993) explained that an integrated approach connects subject areas in ways to reflect the real world, thereby setting learning in the context of human experience and developing a purpose or relevance for the learner (Drake, 1993).

Fogarty (1993) took this idea of integrated curriculum further and broke it down intro several different lenses with which to design curriculum (see Appendix A). Fogarty recommended that educators use the 10 different views of integration as functional prototypes for curriculum design, starting the process by choosing a different model each semester in order to encourage conversation about curriculum coherency. As Fogarty explained,

> These models are just the beginnings. Teachers should go on to invent their own designs for integrating the curriculum. The process itself never ends. It's a cycle that offers renewed energy to each school year as teachers help the young mind discover [the world around them]. (p. 110)

In light of the possible confusion surrounding the terminology of designing a connected curriculum, I refer to Beane's description of a *coherent curriculum* (1995) to discuss this study. His view of a coherent curriculum as, "Parts or pieces connected or integrated in ways that are visible and explicit," (p. 3) fits best with my own view of curriculum integration.

Research on Developing Curriculum Coherency with Science

For the most part, research involving science as a significant contributor to curriculum coherency has revolved around two topics: the commonalities between science and language arts (Akerson & Flanigan, 2000; Baker & Saul, 1994; Casteel & Isom, 1994; Century et al., 2002; Gaskins & Guthrie, 1994; Glynn & Muth, 1994; Rodriguez & Bethel, 1983), and the conflict between views and practice of science and mathematics integration (Frykholm & Glasson, 2005; Kirst et al., 1997; Lehman, 1994).

Science and Language Arts. There has been some discussion in the literature about the common cognitive and metacognitive skills in reading and science process learning (Baker, 1991; Padilla, M., Muth, & Padilla, R., 1991). Critical thinking skills similar to science and reading include making predictions, making inferences, assessing evidence, making conclusions, and using evidence to support an argument. Considering these commonalities, Baker and Saul (1994) suggested, “Teachers with perceived expertise in language arts may feel more comfortable with science and teachers with perceived expertise in science may feel more comfortable with language arts once they realize that many of the underlying goals are the same” (p. 1030).

To further address the potential commonalities between the science and reading Baker and Saul (1994) conducted a study on The Elementary Science Integration Project (ESIP). The 20 teachers participating in ESIP were purposively selected based on a nomination process with the following criteria: expressed long-term commitment to classroom teaching, found satisfaction in learning from and with children, committed to inquiry-based science, and thought critically and coherently about the content and process of teaching (Baker & Saul, 1994).

The focus of the study was to understand the criteria that teachers used to make decisions about their teaching practice and curriculum planning. Therefore, they posed the question: “How does a given teacher decide if a science or language arts idea is worth thinking more about, let alone implementing?” (p. 1025). From an analysis of the teachers’ journals and one-on-one conversations with the teachers, Baker and Saul outlined a list of four considerations for evaluation of science –language arts connections. These considerations included: academic, personal, child-oriented, and practical.

Academic considerations referred to such things as a whole language perspective of authenticity, autonomy, and community that some teachers believed were transferable to science learning; addressing possible misconceptions introduced through children’s literature; and relating to real-world work of readers, writers, and scientists so students can make connections between school and life experiences.

Personal considerations focused mainly on the teachers' reflections of their own learning in ESIP. From their experiences they gained insight then into how their students learned. This realization empowered the teachers in their abilities to make the science-language arts connections and in turn encouraged them to transfer this same sense of empowerment to their students.

The findings on child-oriented considerations included comments from the teachers on how their use of an integration process would impact their students' learning. Baker and Saul noted that they were not surprised to find that the teachers in this project frequently mentioned this theme, because one of the criteria for selection into the program was a teacher's attention to student-centered learning.

The final consideration discussed in this study was practical issues such as "teacher autonomy and decision making, administrative support for innovation, student performance outcomes, and resources and materials" (p. 1032). Baker and Saul summarized,

> There were strong differences among the ESIP teachers in the degree to which they felt they had the power to implement changes in their classrooms that would foster integration. In part these reflect individual differences in personality style, self-confidence, and perspectives of teacher's responsibility and power, but in part they reflect real school-based and administrative constraints on teacher decision making. (p. 1032)

Overall this study raises important considerations for professional development projects and school-based curriculum initiatives that emphasize curriculum integration. The teachers of this study had a positive outlook on science-language arts connections. However, it is important to remember that this was a select group of teachers and not all teachers may have the level of self-efficacy needed to implement such a change to their teaching.

Language arts skills, especially writing skills, can be used to help support the *SFAA*'s goal of scientific literacy (Akerson & Flanigan, 2000). However, Dickinson and Young (1998) explained while instruction in one can complement the other, it cannot substitute for the notion that there are specific instructional needs for each subject area as well. Therefore, Dickinson and Young (1998) described the challenge for integration as needing to show elementary teachers how to use their enthusiasm, expertise, and confidence of teaching one area (in most cases language arts) to support their instruction in the weaker area (most often science).

Akerson addressed this challenge in her elementary language arts methods course (Akerson & Flanigan, 2000). She designed her course to focus on how to use specific reading and writing techniques with the teaching of science concepts. Based on the students' regular responses to journal prompts and course assignments (e.g., read/react papers and developing a thematic unit), Akerson concluded that her students met the course goals, which were: seeing the value of language arts for teaching science; thinking of language arts as a tool for exploring other subjects, in particular science; seeing that by integrating language arts into science more time could be allotted to teach science; and recognizing that skills in language arts can increase competence in science teaching.

Akerson and Flanigan (2000) also noted that science provided the context and language arts provided the tools necessary for the preservice teachers to develop their understanding and confidence in teaching both subjects. Based on their findings, Akerson and Flanigan suggested that interdisciplinary instruction for elementary preservice teachers is beneficial to their preparation and that elementary preservice teachers' comfort level in teaching science may increase when supported with language arts. Teacher educators need to consider collaborating with one another to model that this type of integration is possible in the classroom.

Similar to the Akerson and Flanigan study with preservice teachers, Stoddart et al. (2002) found that science provided the context needed to help English Language Learners (ELL) develop their reading and writing skills. Based on the findings from their study, Stoddart et al. concluded,

> All students can benefit from learning experiences that enable them to use language functions such as describing, hypothesizing, reasoning, explaining, predicting, reflecting, and imagining in the learning of subject matter. The critical point is that language processes can be used to promote understanding of content across all subject matter domains, and that language use should be contextualized in authentic and concrete activity. (p. 684)

In addition to the reading and writing benefits of integrating science and language arts, Rodriguez and Bethel (1983) found that the amount of discussion emphasized in an inquiry approach to teaching science helped English Language Learners (ELLs) improve their oral communication skills. Therefore, Rodriguez and Bethel suggested that ELLs be given the opportunity to learn science using an inquiry-based teaching method. The hands-on experiences and discussion of vocabulary in context will in fact help students with language acquisition, not hinder it.

Science and Mathematics. Although there is a significant amount of literature on the commonalities between science and mathematics (refer to the journal *School Science and Mathematics*), integration of these two disciplines rarely occurs in the classroom. As Kirst et al. (1997) noted from interviewing individuals in various fields of mathematics education, there is definitely a need for teachers to know mathematics when doing science, but for the most part it is a tool for science and there are many more aspects of learning mathematics beyond its use as a tool.

Lehman's study (1994) looked at preservice (n= 161) and practicing (n= 60) elementary teachers' perceptions of integrating science and mathematics. Though both groups agreed that elementary students' learning would benefit from integrating the two subject areas, the practicing teachers indicated that this practice was not happening in schools. Preservice teachers could not respond to this question about the practice of integrating science and mathematics because they were not in classrooms enough to know if "no-integration" was a common practice or not. This finding raises the question, if teachers believe the integration of science and mathematics is doable and beneficial then why is it not occurring? In response to this question the sample of practicing teachers indicated that there is simply not enough time to integrate mathematics and science content.

Besides time constraints, another theme that emerged from the literature on science and mathematics integration was the limitation of teachers' personal experience with integrating the two subjects. For example, Frykholm and Glasson (2005) studied preservice high school mathematics and science teachers' perceptions of integration. They found that preservice teachers saw many benefits to using this approach, but were unsure about how to do it. They received several comments from students like Brian, who said, "My personal experience with integrating math and science has been non-existent" (Frykholm & Glasson, p. 133). When discussing how personal learning experiences has influenced their perception of teaching, another student, Chris, explained

> I feel like I would need to do a lot of research and preparing in order to connect mathematics and science in a meaningful way. I was not exposed to interdisciplinary settings during my school years. The mathematics courses were specialized topics, and so were the [science] courses. Obviously some algebra was used in chemistry and other mathematics was used in physics, but connections were never emphasized. (p. 133)

Similar to the research on teachers' views and practice of inquiry-based science teaching, there is a disconnect between teachers' views and practice of developing a coherent curriculum with the integration of science and other subjects areas. For the most part, teachers described time constraints, but they also noted a lack of personal experience with curriculum integration as being a significant issue in the transfer of their views into practice.

Summary

The call for curriculum coherency is loud and clear. According to the research, teachers agree with the need for making curricular connections. The problem lies in the transfer of these views into practice. This suggests the need for further research that examines classroom teachers who are making this transfer and understanding how they do it.

Professional Collaboration

The fourth research question of this study examines the role of team planning in developing and implementing instructional approaches. As a means of discussing group practices, I reviewed Wenger's (1998) concept of *communities of practice* (CoP). This social theory of learning provided a theoretical context with which to describe the collaborative practice of the teaching team in my study. In addition to the concept of

CoP, the research on team teaching provides a context for describing the interactions of teachers when working collaboratively together.

My purpose for examining a CoP is to understand the role of participation and how learning develops as a result of one's social participation in the community. Wenger (1998) referred to participation as not just how one engages in the community, but how identities are constructed in relation to the community. To fully understand the learning that occurs in a CoP, Wenger explained that four components need to be studied. These are: community – learning as belonging, meaning – learning as experience, practice – learning as doing, and identity – learning as becoming.

With regards to team teaching, the research for the most part is focused on higher education rather than K-12 classrooms, even though a part of the reform movement discusses the need for developing small learning communities for teachers (Silva, 2000; Supovitz, 2002). Silva (2000) explained that to better understand curriculum implementation, research needs to be done in a practical sense at the classroom level. Although teachers refer to published curriculum materials to plan their teaching, it is their conceptualization of those materials that determines how students interpret the information.

Research on Teacher Collaboration

Wesley and Buysse (2001) compared a community of practice (CoP) to that of a learning organization. They explained that a CoP "emerges from a common desire among its members to achieve change (i.e., improve existing practices) [and] it provides regular opportunities for collaborative reflection and inquiry through dialogue" (p. 118).

This practice of ongoing reflection and inquiry are commonly found in CoPs created in educational settings.

Manouchehri's study (2001) investigated how two pairs of mathematics teachers interacted in order to understand what contributions each member of the pair brought to the CoP and how the peers felt their partner's contributions improved their teaching practice. One pair indicated some change in their professional practice after seven months of working together, the other pair did not. Manouchehri learned that an effective CoP requires effort from all members and that perhaps there needs to be some support or guidance during its initial development from an outside source (e.g., a professional developer). She suggested the roles that participants take on within a community are critical to the CoP's success and sustainability. For example, in Manouchehri's study, because Julie took initiative, her partnership with Doug demonstrated change in their individual identities, the development of their intimate community of two, and the meaning of the partnership experience for both of them. Julie realized early on that she was not getting what she needed to improve her mathematics teaching based on the early structure of her collegial relationship with Doug. In an attempt to remedy this issue, she became more focused with her requests to Doug. She asked him to observe her teaching and provide feedback about her students' learning and her mathematics teaching methods. Julie realized early on that she needed to take some control of the situation; she devised a plan that would give her what she needed, as well as help Doug with refining his role within their small community.

It was important for the success and sustainability of their CoP that they had defined roles; their learning developed as a result of their discussions with one another.

The CoP served a purpose in each others' learning. As Wenger (1998) stated, "We all have our own theories and ways of understanding the world, and our communities of practice area places where we develop, negotiate, and share them" (p. 48). So even though Julie needed to be explicit with her requests in the beginning, over time and with continued dialogue with Doug her needs became tacit in their community of practice.

Foulger (2005) conducted a study that took place in a K-8 urban school setting and looked at how CoPs in a technology integration professional development project developed. More specifically, Foulger was interested in learning how the professional developer's skills and behaviors influenced the five members of the CoP, who represented various teaching responsibilities, years of teaching experience, and knowledge of technology integration. The focus of this study was on the role of the professional developer with respect to the development of the CoP. First, the researcher found that the teachers were encouraged to commit to the common experience which allowed all participants to actively engage and feel comfortable in taking risks. To support this idea of commitment, CoPs need attention given to developing collaborative practices of reflection. For the CoP in this study, collaborative reflection practices created a stronger sense of understanding about the topic of technology integration. Second, a sense of interdependence needs to be created so teachers feel as though they can turn to their community for support when things become stressful. And third, "all participants must recognize not only that they are learning for their own good, but also that they are vital elements in organizational change efforts" (Foulger, p. 10). Foulger suggested that the findings from this study support a shift in professional development "from a traditional approach to a more community-based approach" (p. 13).

Although Silva's study (2000) did not specifically focus on development of CoPs, her findings provide a deeper understanding of the dynamics of team teaching. Her study looked at three teams of teachers with very different demographics and experiences with curriculum planning. The purpose of Silva's study was to share the experiences these teachers encountered and describe how each team made sense of the new language arts and social studies integrated curriculum. Silva (2000) explained,

> Evidence from this study suggests that teams do not enact curriculum. Instead, teams become vehicles for curriculum decision making…In many districts, a movement exists to ensure that curriculum looks the same in each classroom across all schools…[However], participation by teacher teams in debate, deliberation, and choice will result in the implementation of curriculum that will most likely not look the same across contexts. (p. 292)

To develop a better understanding of team teaching, Silva suggested the need for gaining a deeper appreciation of the essence of the teachers' experiences as part of the team, their beliefs, and their actions.

Summary

When teachers are afforded the opportunity to work with colleagues, the quality of their teaching improves. Through the interdependent network of a CoP, teachers reflect with one another and are more willing to take risks in their teaching. Further exploration is needed into the interaction of professional collaborations in educational settings, such as teachers' CoPs and team teaching. Further support of these kinds of organizations requires an understanding of the various roles members play within the community and how decision-making occurs within the team. Studies examining these two issues may lead to further understanding of how professional collaboration stimulates teachers' learning and improves teaching.

Gaps in the Literature

From my review of the literature on elementary teachers' views and practice of science, I noticed a need for further research that examines elementary teachers' views and practices in science teaching and how those views and practices connect with other curricular areas. A significant amount of literature exists that describes the disconnect between teachers' views of how to teach science and their practice of those views. Both external (e.g., time, support, and resources) and personal (self-efficacy and lack of experience) factors constrain teachers from implementing their views. Therefore, there is a need to study how teachers' views translate to practice. According to Crawford (2000) this type of research needs to occur at the classroom level with practicing teachers.

The literature also reveals a similar disconnect between teachers' views and practice of integrated teaching, for example in integration of science and mathematics. Therefore, there is a need for further research into the design of coherent curriculum. Moreover there is a need for studies that examine how teachers' translate their views about designing a coherent curriculum into practice.

Finally, there is limited research that examines professional collaboration. There is a need to study the dynamics of a teacher-developed community of practice in order to understand how such groups form, the roles of the members, the purposes of the group, how they maintain their group's professional development, and how the group influences practice.

The significance of my study is to address some of these gaps in the research literature by 1) studying a team of experienced elementary classroom teachers, 2) developing an understanding of how they teach science and how their teaching of science influences their teaching of other subjects, and 3) examining the role their professional collaboration plays in their teaching.

CHAPTER THREE: THE RESEARCH PROCESS

Qualitative research is philosophical in nature; it is guided by a researcher's belief of how s/he "sees the world and acts in it" (Denzin & Lincoln, 2000, p. 19). A researcher's beliefs are guided by the ontological, epistemological, and methodological principles for studying a particular phenomenon, and are referred to as a paradigm or an interpretative framework. In particular, this qualitative study was guided by a constructivist-interpretative paradigm because of the focus on a particular case of four teachers and their instructional methods. According to Denzin and Lincoln (2000), "The constructivist paradigm assumes a relativist ontology (there are multiple realities), a subjectivist epistemology (knower and respondent co-create understanding), and a naturalistic ([set] in the natural world) methodological procedures" (p. 21).

From an ontological perspective, the multiple realities of this study include the researchers' and four teachers' individual views of designing and implementing a coherent curriculum. The subjectivist epistemological views of this study are associated with a constructivist paradigm, which lent me the opportunity to interpret my observations, as well as ask the teachers clarifying types of questions about my interpretations throughout my investigation, thus generating an understanding about the nature of the teachers' instructional intentions and methods. Because of the unique nature of this team of teachers, a case study design was appropriate for the design of this study. This allowed me to narrate these teachers' experiences as a "passionate participant, [and] as [a] facilitator of multi-voice reconstruction" (Lincoln & Guba, 2000, p. 166).

Research Questions and Tradition

Designing a strategy for my research involved three aspects: 1) clarifying the purpose of the study, which included exploring the context of my study to assist me in developing my research question and potential sub-questions; 2) deciding on what information was needed to answer these specific questions; 3) selecting a research tradition that was most effective in obtaining the needed information. As Denzin and Lincoln (2000) described, "A research [tradition] describes a flexible set of guidelines that connect theoretical paradigms first to strategies of inquiry and second to methods for collecting empirical material" (p. 22).

The purpose of my research was to understand the role that science played in planning their curriculum and how their teaching of science influenced their teaching of other subjects. The overarching research question was: How does a team of second grade teachers teach science and how does this influence how they teach other subjects? In order to answer this question, I developed the following sub-questions.

1. How do these teachers view and teach science?
2. What role does science have in designing their curriculum?
3. How do they apply their approach for teaching science to their teaching of other subjects?
4. What is the role of team planning?

These questions focus on the experiences of this team of teachers and my interpretations of their teaching practices. A research tradition of phenomenology and a case study methodology guided me in designing and implementing this study.

Phenomenology

The term "phenomenology" has been adopted by several social science fields and as a result has become difficult to define. One of the first well-defined meanings of phenomenology was constructed by the philosopher Hegel (1770-1831) in which "phenomenology referred to knowledge as it appears to consciousness, the science of describing what one perceives, senses, and knows in one's immediate awareness and experience" (in Moustakas, 1994, p. 26). However, it was not Hegel's influence but Descartes' that supported Edmund Husserl's development of the concept of Epoche, a critical aspect of reflection for a phenomenological researcher to consider.

> Epoche requires the elimination of suppositions and the raising of knowledge above every possible doubt. For Husserl, as for Kant and Descartes, knowledge based on intuition and essence precedes empirical knowledge. Although the doubt of Descartes was transformed in the Epoche of Husserl, both philosophers recognized the crucial value of returning to the self to discover the nature and meaning of things as they appear and in their essence. (Moustakas, 1994, p. 26)

"In the Epoche, the everyday understandings, judgments, and knowings are set aside, and phenomena are revisited, freshly, naively, in a wide open sense, from the vantage point of a pure or transcendental ego" (Moustakas, p. 33). I have enacted epoche within this study through the use of a member check system (Janesick, 2000). During my interviews I probed with questions for clarification about methods or terms that participants used to describe their teaching approach and I used a standardized interview protocol for each participant to ensure I was asking the same questions to each for consistency. Also, as I conducted my field observations I took a few moments each day to speak with the other members of the team that I did not observe that day about what they taught, how they taught it, and the nature of their class discussions. The purpose of these informal conversations was to provide me with all the pieces necessary to develop a whole picture of how each teacher, as well as the team, delivered a coherent curriculum. As I collected my field notes on the teachers classroom practice and team meetings, I occasionally wrote brief reflections discussing what I had observed in relation to my research questions. These reflections varied from a few brief sentences to notes in the margins of field notebooks. Sometimes I posed questions to myself and other times I described a theme I felt was emerging from my data. These reflections were my initial phase of analysis and it was at this level of epoche that the purpose of my study was refined to how this team's science teaching influenced their teaching of other disciplines.

The ontological perspective of a phenomenological study is that there is no separate reality for the people involved in which only they know what their experience is and what it means. In addition, the epistemological core, or the nature of knowledge of the phenomenon studied, is the essence of the shared experience for the participants involved (Patton, 2002). Therefore, the central question to a phenomenological study asks, "What is the meaning, structure, and essence of the lived experience of this phenomenon for this person or group of people" (Patton, 2002, p. 104). Van Manen (1990) elaborated on this idea by explaining that "phenomenology asks for the very nature of a phenomenon, for that which makes a some 'thing' what it *is*–and without which it could not be what it is" (p. 10). The phenomenon experienced by the participants may be an emotion, a relationship, a program, a culture, etc. However, according to Patton (2002), "One can employ a general phenomenological perspective to elucidate the importance of using methods that capture people's experience of the world without conducting a phenomenological study that focuses on the essence of shared experience" (p. 107). Therefore, phenomenology can be viewed as a perspective and/or a method (Patton, 1990). If it is viewed as a perspective, then the focus is on "what people experience and how they interpret the world (in which case one can use interviews without actually experiencing the phenomenon oneself)" (p. 70). But, viewing phenomenology as a "methodological mandate [means the researcher must] actually experience the phenomenon being investigated (in which case participant observation would be necessary)" (p. 70). In this study, I focused on the teachers' experiences and conducted interviews with each of them, but I also observed their experiences first-hand in order to provide support for what they were saying. Thus, I employed the research tradition of phenomenology, from both a perspective and a methodological mandate.

Context of the Study

School Environment

This study took place at Drake Elementary School (pseudonym) which is one of nineteen elementary schools situated in a growing Midwest community. According to the school district's database, the total school population for Drake in 2004-2005, the year of the study, was 465 with 86 students split among the four 2nd-grade classrooms involved in this study. The overall racial composition of student population was: White: 351 (75.5%), Black: 83 (17.8%), Hispanic: 13 (2.8%), Native American: 3 (0.6%), Asian: 15 (3.2%), for a total minority population of 24.5%.

In grades K-3 at Drake Elementary, the classroom teacher is responsible for teaching the content areas of communication arts, science, mathematics, social studies. Their students go to teacher specialists for art, music, and physical education. These specialists are shared by the other teachers in the school; therefore, the students do not attend these three subjects on a daily basis. It is during this specialist time period that teachers at Drake take the opportunity to plan their instruction and confer with one another about lessons they have taught.

School Curriculum

The curricular structure at Drake Elementary went through several changes in the decade before this study. Around 1995, the then-principal of Drake Elementary School, who was a proponent of the Basic School model developed by Ernest Boyer (1995a), had the entire staff of Drake Elementary participate in a school-wide book study of Boyer's book *The Basic School: A Community for Learning* (1995a). Boyer's program provided them with a framework to reorganize their school's vision for learning, placing an emphasis on community, curriculum with coherency, collaboration, and core virtues. The Basic School program was designed around the following belief:

> Young children don't think about categories of knowledge. They follow their curiosity wherever it leads. They are, above all, natural, integrative learners. I concluded [from my studies] that the elementary school, especially, should be organized around a curriculum that is both comprehensive and coherent. (Boyer, p. XVIII)

Three years prior to this study, the principal responsible for bringing the Basic School philosophy into Drake Elementary school retired. Her replacement came from within the Drake Elementary School community and continued to support the school's focus on the Basic School model.

Two to three years before this study, however, there was a significant shift in the school district towards more literacy-based programs at the primary grade levels. This caused Drake Elementary to refocus their curriculum from the integrated thematic approach that had been driving their school for the previous 7-8 years to more of a segregated discipline approach. A bill passed the legislature at the state level that required all students to be reading on grade level by the end of fourth grade or they would be retained (with exceptions for students with special needs). Because of these external pressures, Drake Elementary had to modify much of its curriculum to ensure their students achieved the state's and district's revised literacy expectations. Even though Drake no longer followed Boyer's specific philosophies as closely as they once did, at the time of this study the school's principal and the second grade teachers each said that many of the curricular ideas outlined in the Basic School model remained a part of their teaching beliefs and practice.

Participants

The main participants in this study were four second grade teachers who I have identified throughout this study with the pseudonyms Tracy, Brenda, Heather, and Nancy. I purposively selected these four teachers because of various past professional experiences with Tracy, Brenda, and Heather. Although I had not had any prior interactions with Nancy, she agreed to participate because of the collaborative nature of the team's approach to teaching. The principal of Drake Elementary also agreed to be interviewed for this study and provided information related to the context of this study and the nature of the second grade teaching team in relation to the other teachers at Drake. At the time of this study, the principal was in her fourth year as administrative leader of Drake Elementary. Prior to her role as principal, she taught for in the classroom for 20 years and had experience teaching all grade levels K-3.

I had worked with Tracy in variety of professional situations over the two years when she was on a leave as a regular classroom teacher to be a mentor teacher with the university's fellowship program. I first worked with her for three university semesters when I was teaching an interdisciplinary methods course for elementary preservice teachers. As part of her mentoring responsibilities, she advised some of my students who were working at Drake Elementary to complete their field experience requirements. During these three semesters, Tracy met with me and other university instructors on a monthly basis to discuss course requirements and interdisciplinary curriculum design. Also, in January-May 2004, Tracy and I taught separate methods courses to the same group of preservice teachers. During that semester, we collaborated on two integrated teaching experiences and met bi-weekly with a third instructor to discuss teaching strategies and issues within the course block.

At the time of this study, Tracy was in her 16th year of teaching. Over those 16 years she taught grades K-4, with the majority of her teaching time (11 years) at the second grade level. She explained that using an integrated approach to teaching had always played a significant role in her teaching practice, especially with her curricular design experiences during Drake's early years of following the Basic School model.

My previous connections with Brenda and Heather were not as extensive as those with Tracy, but I did have several opportunities prior to the initiation of this study to observe their teaching. For two semesters (January-May, 2004 and August-December, 2004) some of my early childhood preservice students were placed in their classrooms to complete classroom-based field requirements. During my frequent visits to their classrooms to observe my students, I became increasingly more intrigued with Brenda and Heather's approaches to teaching science and the curricular connections they were making.

In addition to these visits, I also had the opportunity to interview Brenda's for the purpose of gaining an elementary teacher's perspective about the current state of science in elementary schools. At the time of this study, Brenda was in her 13th year of teaching. Similar to Tracy, Brenda had experience teaching several of the primary grade levels, although the majority of her teaching was split between two different schools teaching second or third grade. Brenda explained that the key to her teaching was to use an inquiry approach across all disciplines. Although she felt science and math lent themselves most easily to this approach, she also stated that the more comfortable she became with inquiry, she also found ways to apply inquiry-based practice to her teaching of reading and writing.

Heather had 14 years of teaching experience, all of which were in the second grade at Drake Elementary. She admitted that at the beginning of her teaching career that she preferred to teach mathematics, but over the years she grew to love and appreciate teaching science.

The fourth teacher of the team, Nancy had nine years of teaching experience at the time of this study with seven years at the second grade level at a school other than Drake, and two years as a Title 1 Reading teacher at Drake. Due to a cut in funding, the Title 1 position at Drake was removed, but the principal offered her a regular classroom position on the second grade team instead. Nancy believed that her main contribution to the team was her strengths in reading and writing, which was why she was selected to run the pullout reading program for the second grade students needing additional literacy support. This meant that she did not teach any of the science lessons that I observed, but she still contributed to the team planning sessions and taught other disciplines that I observed (reading, writing, and mathematics).

Second Grade Curriculum

The teachers received their science curricula through a district-wide kit rotation program. In most cases teachers have the kits in their classrooms for 4-6 weeks. The science unit/kit I observed this team teach was called *Changes*, which is part of the second grade *Science and Technology for Children* (STC) program (National Science Resources Center [NSRC], 1998a).

Brenda, Tracy and Heather all had several years of teaching experience with the *Changes* unit. Their first experience with the *Changes* unit was in the late 1990s when Drake Elementary School volunteered to participate in the school district's curriculum pilot program. In addition to piloting the unit, Brenda was asked to be a member of the district's curriculum adoption committee for this particular science kit and led several state-wide presentations on implementing this program in classrooms.

Therefore, teaching the *Changes* unit was not a new experience for Brenda, Tracy or Heather. The three of them had taught the *Changes* unit for several years and each year they collaborated to decide what aspects of the unit they wanted to use, modify, and supplement in order to keep the learning experiences the same across all their classes. They explained that any modifications or supplements they made to the *Changes* unit depended on the learning needs of their students, which varied each year, as well as the specific learning outcomes or district expectations their students needed to achieve.

The purpose of the *Changes* unit (NSRC, 1998a) is to provide students with hands-on experiences with exploring their understanding of changes of state for solids, liquids and gases. In addition to meeting expectations in the physical sciences, the *Changes* unit (NSRC, 1998a) covered topics from earth science such as the water cycle.

The STC program places a strong emphasis on both the abilities necessary to do and the understandings about scientific inquiry, as outlined in the *Standards* (NRC, 1996; 2001). The goals of the STC curriculum are to:

- Make science relevant, interesting, and challenging for all children.
- Contribute to children's conceptual understanding of their world.
- Help children develop scientific-reasoning and problem-solving skills.
- Foster the development of scientific attitudes, such as curiosity, respect for evidence flexibility, and sensitivity to living things.

(National Science Resources Center [NSRC], 1998b)

Each STC unit incorporates a four-step instructional model, which the curriculum refers to as the STC™ Learning Cycle (NSRC, 1998b). The four steps include: *focus* – gathering information on students prior knowledge and experience with the topic of study; *explore* – the students complete a sequence of activities to study the phenomenon; *reflect* – using science journals and class discussions the students analyze their findings and infer conclusions; *apply* – students are given the opportunity to test their understanding about the phenomenon to real-life situations and make connections to other parts of their curriculum (NSRC, 1998b). This four-step learning cycle expands on the 3-phase learning cycle first described by Atkin and Karplus with their development of the Science Curriculum Improvement Study (SCIS) (Atkin & Black, 2003; DeBoer, 1991; SCIS, 1970). Overtime, the Atkin-Karplus learning cycle has been modified by many researchers and curriculum developers to include several other phases, but at the core of each learning cycle model is the idea that students need to first explore the phenomenon, then use evidence to provide explanations about the phenomenon, and finally apply their understanding of the phenomenon to other situations (Atkin & Black, 2003; DeBoer, 1991; Abraham, 2003; Abraham & Renner, 1986).

For mathematics, the teachers used TERC's elementary series called *Investigations in Number Data and Space* (2004). All elementary schools across the school district were required to use this mathematics series. While, the teachers followed the structure of the *Investigations* series the majority of the time they would occasionally supplement with a lesson from the *Math by all Means* series (Confer, 1994). Supplementing the curriculum with these other materials provided the teachers with the additional support or practice they felt their students needed.

As for their literacy program, the teachers did not have a specific series they followed. Instead, they developed their reading and writing lessons based on ideas they gathered from either professional development workshops or professional book clubs. Each classroom had an extensive collection of children's literature that their students could access at any time.

Design of the Study

I selected Drake Elementary School for my study, and in particular the four second grade teachers, because of their dedication to the Basic School's principle of developing a coherent curriculum around the core commonalities of the subject areas. More specifically, I was interested in understanding the teachers' use of the second grade science curriculum as a foundation for designing their coherent curriculum. Having previously worked with and observed three of the four second grade teachers, I found that their regular teaching of science and overall sense of curriculum coherency made them an ideal case to study.

Case Study Approach

Stake (2000) explained that a "case study is not a methodological choice but a choice of what is to be studied" (p. 435). Furthermore, Patton (2002) described case analysis as "organizing the data by specific cases for in-depth study and comparison. Well constructed case studies are *holistic* and *context sensitive*, two of the primary strategic themes of qualitative inquiry" (p. 447). Cases are a "specific, unique, bounded system," (Stake, 2000, 436) which is purposefully sampled to study a specific phenomenon occurring within a set of individuals, a group, a culture, or an organization. "The case study approach to qualitative analysis constitutes a specific way of collecting, organizing and analyzing data; in that sense it represents an analysis *process*…The analysis process results in a *product*: a case study" (Patton, 2002, p. 447).

For the purpose of this research I selected a case study approach to guide my collection and analysis of data. I used this approach in conjunction with a phenomenological research tradition because of the unique experience of the team of teachers studied. Stake (2000) would describe this study as an *intrinsic case* study because my goal was to better understand this particular case of teachers. I did not select to study this team of teachers to make sense of an abstract concept or generic phenomenon. Instead, this case illustrated a particular experience shared by these four teachers only, and it was their distinct experiences that I wanted to understand; for me, this case itself was of particular interest.

As Mitchell (1984) explained,

> A good case study enables the analyst to establish theoretically valid connections between events and phenomena which previously were ineluctable. From this point of view, the search for a “typical” case for analytical exposition is likely to be less fruitful than the search for a “telling” case in which the particular circumstances surrounding a case, serve to make previously obscure theoretical relationships suddenly apparent. (p. 239)

This teaching team was an example of a telling case because of the teachers' dedication to teaching science in a primary classroom and their dedication to developing curriculum coherency. Subsequently, I refer to the four teachers as a single unit of study for analysis and look to their experience as a whole rather than comparing their individual teaching practices.

Role of the Researcher

I followed three steps to gain access to study the instructional approach this team of teachers used. First I contacted Tracy, my primary contact with the second grade teaching team, and proposed my research plan to her. She offered to speak with her teammates informally to see if they would be willing to let me conduct my research with their whole team. I received an email confirmation from Tracy saying the team had agreed to participate in my study (Appendix B). Next I approached the principal of Drake Elementary to receive approval to conduct my research in her school and to ask her to participate in an interview. She gave me verbal consent at this time. Lastly, I submitted a *Request for Research* application (Appendix C) with the school district and received a letter of approval from them on November 3, 2004. Concurrently I was approved by my university's Institutional Review Board to conduct this research.

My interest in designing integrated curricula first developed from my experience as an Outdoor Educator. The outdoor learning environment is a complex system, so naturally it requires learners to draw from their prior experiences in many ways. In particular, an outdoor learning environment is a sensory experience that encourages learners to question, explore, and communicate in a variety of ways, while examining the interactions of the world around them. Throughout this experiential process learners rely on a variety of interpretative lenses, which they have constructed over time as a result of developing both a personal and a theoretical knowledge-base.

My first teaching experience as a doctoral student was an elementary curriculum integration methods course. In reading to prepare for teaching this course I found several models for designing an integrated curriculum. However, none aligned with my Outdoor Educator views of integration as much as Drake's (1993) description of an interdisciplinary curriculum. She describes an interdisciplinary approach to curriculum integration as using common critical thinking skills, such as questioning, inferring, predicting, hypothesizing, and communicating, as the building blocks for designing a connected curriculum. It is this interdisciplinary view of curriculum coherency that acts as my lens for interpretation in this study.

This study focused on the teachers' experiences and views of how their science teaching provides a foundation for connecting their curriculum. Thus, I felt it was important for the credibility of this study that I assume the role of close observer rather than a participant observer. Van Manen (1990) referred to the act of observing closely when one "assume[s] a relation that is as close as possible while retaining a hermeneutic alertness to situations that allow [them] to constantly step back and reflect on the meaning of those situations" (p. 69). By keeping notes in my journal about my own views of curriculum coherency and establishing myself in the classroom as a close but not a participant observer, I was able to maintain the reflective nature required of this phenomenological case study.

The teachers also viewed me as an observer and not a participant. They were open to conversations with me before and after their teaching, as well as when the students were doing group work independent of the teacher's instruction. The teachers expected me to share with them generalizations about their teachings that I observed, but did not look to me to provide them with formative feedback about their teaching or their students' learning. They understood that the purpose of my study was to gather information on their regular routines and strategies for teaching science, reading, writing and mathematics, with as little modification as possible occurring to their instructional plans because of my presence.

Data Collection

As Van Manen (1990) explained, " One needs to guard against the temptation to let method rule the question, rather than the research question determining what kind of method was most appropriate for its immanent direction" (p. 66). Therefore, considering the research questions for this qualitative study, it was clear that I needed to observe (the experiential anecdote) and interview (the personal story) the teachers about their practice. Written consent was collected from all interviewees prior to conducting any interviews (Appendix D). These consent forms, as well as all audiotapes, will be kept in a locked drawer for a minimum of three years following the conclusion of data collection.

I collected field notes in two different settings: 1) during team planning sessions, and 2) in individual teachers' classrooms. I observed the team meetings for 1 ½ hours each week for 10 weeks. The meetings took place on Tuesday and Thursday afternoons during the school day and served two purposes. The Tuesday meeting afforded the teaching team the opportunity to reflect on what they had taught at the end of the previous week and how they had carried forward during the current week, and consider their teaching direction for the remainder of the week. The Thursday meeting acted as a checkpoint for the teachers; they often shared anecdotes about things their students said or did that may have shifted their thinking about their lessons for that week.

The second setting for observation data was the teachers' individual classrooms. The purpose of these observation periods was to gather data on how the teachers connected the content areas of science, mathematics, reading and writing. I observed the teachers' classrooms during the same length of time as the team meetings, from January to mid-March 2005. Overall, I gathered observational data on two and a half science units, but focused the majority of my data gathering on the first 6 weeks with the *Changes* unit, which examined changes in properties of matter and changes of state.

I spent the majority of my final three weeks observing the teachers' classrooms during reading, writing, and mathematics lessons. It was during these last few weeks that I had the opportunity to observe Nancy teach. Science was taught at the same time each morning (10:00-11:00 am) on Monday, Tuesday, Thursday, and Friday each week. Mathematics was the first subject everyone taught in the morning and the afternoons were focused on literacy (reading and writing together).

For the first six weeks of the observation period, I rotated each day among Tracy's, Brenda's, and Heather's classrooms to observe their science teaching. My reason for observing their science teaching for so long was to get a sense of continuity between their lessons, as well as contrast their teaching styles. With this information, I was able to connect their teaching methods in science to how they taught reading, writing, and mathematics.

I observed Nancy for one mathematics, reading, and writing lesson over the course of the 10 week observations period. Her students were divided into the other three classrooms for science; during that time she conducted additional pullout reading groups for the second graders who needed extra support. However, I believed it was important to also observe how she connected science teaching methods into her instructional strategies for mathematics and literacy.

In addition to these individual classroom observations, each day I also informally gathered information on the science instruction taught in the other two classrooms that morning. For example, if I observed Tracy's science teaching, then I asked Brenda and Heather a few questions regarding their learning objectives for their science lesson that morning. This informal inquiry often focused on questions such as: What was your learning objective for today's science lesson and how did you approach teaching this topic? What experience(s) did you provide your students? How do you perceive your students' understanding of today's lesson?

I used a standardized open-ended interview protocol (Patton, 2002) as a second primary data source. Patton described a standardized open interview approach as

> A set of questions carefully worded and arranged with the intention of taking each respondent through the same sequence and asking each respondent the same questions with essentially the same words. Flexibility in probing is more or less limited, depending on the nature of the interview and the skills of interviewers. The standardized open-ended interview is used when it is important to minimize variation in the questions posed to interviewees. (p. 342)

I conducted a single open-ended interview protocol with the principal before I began my 10 weeks of observation (Appendix E) for the purpose of gathering background information and to establish the context of my study. The questions for this interview covered three topics: 1) a description of the Drake's history with designing curriculum and in particular how it had changed over the 10-15 years prior to this study; 2) a comparison of the second grade teachers' instructional methods to those used by their colleagues; 3) a discussion on the principal's view of the role that science played in Drake's curricular practices.

I conducted two interviews with the teachers, one at the beginning and one at the end of the 10 week observation period. The first interview (Appendix F) provided data that addressed research questions one, two and four, which examined the teachers' views and approach to teaching science, the role of science in designing their curriculum, and the role of team planning. I realized while observing the *Changes* unit that I was already beginning to understand some things about how the teachers view and teach science. I constructed my second interview protocol to focus on how their approach to teaching science influenced their teaching of other subjects. This interview (see Appendix G) provided data to answer research questions three and four about the instructional connections between science and other subjects, as well as additional information about the role of team planning in making the connections.

I transcribed the principal's interview and the teachers' second interviews verbatim. However, I did not transcribe the teachers' first interviews. Instead, I reviewed the recordings of the teachers' first interviews to gather quotes and details from their responses.

I did not tape record any of the daily informal discussions I had with the teachers following my observations; instead I summarized these conversations into my field notes for that day. I tape recorded and took notes during the team meetings, but I did not transcribe those tapes. Since my field notes were quite detailed, I decided to refer to these for analysis; when I had a question about my notes, I referred to the audiotapes for clarification.

During my observations of classroom instruction and team meetings, there were a few times when I collected copies of handouts, schedules, or wrote down the notes charted by the teacher during a lesson. I collected these documents as secondary data sources to support the analysis of my field notes.

A phenomenological study draws from multiple data sources in order to provide the researcher with enough details to accurately interpret and describe the participants' experiences with the phenomenon. Table 2 illustrates how each of the data sources described above informed the research questions associated with this study. Organizing the data sources according to the research questions provided a method of data management (data reduction) and initiated the data analysis process.

Data Analysis

As I moved from data collector to data analyzer, the need to bracket my own views of curriculum coherency (Van Manen, 1990; Morse & Richards, 2002; Patton, 2002) became increasingly important. Van Manen (1990) described bracketing as the suspension of one's beliefs about a phenomenon "in order to study the essential structures" (p. 175) of the phenomenon being studied. In addition to bracketing each of the participants' views about how they teach their curriculum, it was also critical for me

Table 2

Data Collection Matrix

Research Question	Data Sources
How do these teachers view and teach science?	• Teacher Interview #1 • Principal Interview • Classroom Observation Notes
What role does science have in designing their curriculum?	• Teacher Interview #1 • Principal Interview • Classroom Observation Notes
How do they apply their approach for teaching science to their teaching of other subjects?	• Teacher Interview #2 • Classroom and Team Planning Observation Notes • Artifacts
What is the role of team planning?	• Teacher Interview #1 and #2 • Team Meeting Notes

to bracket my own views so that I could compare and reflect on the essence of the shared phenomenon fairly. Bracketing is part of the reduction process of a phenomenological study that allows the researcher to get to the core meaning of the experience for the participants (Van Manen, 1990; Patton, 2002).

As part of the bracketing process, I periodically wrote about my assumptions, knowledge, and expectations about curriculum coherency and science teaching as I was analyzing the data. I would then compare those notes to the data I was coding in response to my research questions. The act of bracketing helped to make me aware of how my own biases were influencing my interpretations of the data.

For a phenomenological case study, the focus must remain on how the participants experience the phenomenon. During data analysis, themes emerged that contributed to a narrative of the experience. This integrated mode of examining themes across participants' stories resulted in developing a rich description of their shared experience (Patton, 1990). Using a single case study approach for data analysis afforded me the opportunity to examine and report on these teachers experiences as a unit rather than individually. Since team collaboration played a vital role in this team's teaching, it was critical to define the team as the unit of analysis. This method of data analysis assisted me in staying focused on the purpose of my study, which was to construct an understanding of how this particular *team* of second grade teachers taught science and how *their* approach to teaching science influenced their teaching of other subjects.

Following one set of interviews with each teacher and an interview with the principal, I reviewed my notes and developed a list of instructional methods I could use to guide my observations and field notes. Some of these instructional methods included: an inquiry-based approach to teaching science, the emphasis on developing students "cognitive abilities to do scientific inquiry in science" (NRC, 2000, p. 18), the threading of these cognitive abilities across the other subject areas, and the teacher's role throughout a lesson with regard to questioning and management.

Following my observations of the *Changes* unit, I wrote preliminary thoughts about the emerging themes I observed in Tracy's, Brenda's, and Heather's instruction (Appendix H). This act of reflection allowed me to begin bracketing some of my personal views about curriculum coherency (Wolcott, 1995), and made me aware of the emphasis placed on the cognitive abilities of scientific inquiry in this second grade curriculum. Also, this reflective practice made me realize that I needed to amend my second interview questions to focus more on the teachers' emphasis of an inquiry-based approach to teaching and how this was threaded throughout their curriculum. I also altered my research questions to focus more on the teachers' science teaching views and practice as a whole and less on the collaborative strategies employed by the team.

The teachers' interviews were primary data sources. I coded them for comments related to the teachers' views and teaching of science, the role of science in designing the curriculum, connections between teaching science and other subjects, and the role of team planning. Thus, I employed a content analysis process, a technique often associated with case studies. Patton (2002) described the process of content analysis as the "reduction and sense-making effort that takes a volume of qualitative material and attempts to identify core consistencies and meanings" (p. 453). The content analysis process I employed on the teachers interviews involved two phases: 1) aligning the teachers' responses to both sets of interview questions to the research questions, and 2) reviewing the teachers' responses for patterns that I could then develop into assertions to answer the research questions. Table 3 shows the grouping of the interview questions in relation to the research questions for this study. Note that a few questions from the teachers' first interview were less relevant to the revised questions.

I reviewed the principal's interview to find details that referred to the teachers' views of science and the role of team planning. The principal's interview also provided an historical context for the study regarding the school's learning environment and curriculum design.

Table 3

Content Analysis Matrix of Teachers' Interviews

Research Question	Interview One Questions [a]	Interview Two Questions [b]
How do these teachers view and teach science?	3, 4, 6	1, 4, 5, 7, 8
What role does science have in designing their curriculum?	5, 7	2, 3, 12
How do they apply their approach for teaching science to their teaching of other subjects?		6, 9
What is the role of team planning?	8, 10, 12	10, 11

[a] See Appendix F for interview protocol one. [b] See Appendix G for interview protocol two.

Field notes served as another primary data source in this study. I analyzed these notes according to the research questions, but instead of looking at specific events within a lesson, I used a single lesson as a unit of analysis in order to construct a thorough understanding of each teacher's cycle of instruction for each subject (science, mathematics, reading, and writing). Having used this form of content analysis to analyze the classroom and team meeting observation notes, I developed vignettes that represented the team's common instructional practice for each discipline. I analyzed artifacts collected throughout the study within the context of these vignettes.

Throughout the data analysis process, I consistently reviewed portions of my findings with my advisor, peers, and the teachers participating in this study. These conversations assisted me in making sure that my assertions directly answered my research questions and that the evidence I was using to support these claims worked. From these conversations, as well as continuing to review the literature, I was able to see how the questions fit into the bigger picture of answering the overarching research question: How does a team of second grade teachers teach science and how does this influence how they teach other subjects?

Trustworthiness

One question is often asked of qualitative research is how the results of one study can be "generalized" to a similar situation. As Cronbach concluded,

> social phenomena are too variable and context bound to permit very significant empirical generalizations… generalizations decay. At one time a conclusion describes the existing situation well, at a later time it accounts for rather little variance, and ultimately is valid only as history. (as cited in Patton, 2002, p. 582)

Within the realm of a constructivist-interpretative paradigm, such as a phenomenological case study, the notion of making generalizations from the data is often identified as the *transferability* or *fittingness* of the data to other contexts. Lincoln and Guba (as cited in Patton, 2002) explained, "The degree of *transferability* [is] a direct function of the *similarity* between two contexts, what we shall call '*fittingness*'. Fittingness is defined as a degree of congruence between sending and receiving contexts" (p. 584). The thick description I provided will help other researchers and teacher practioners judge the fittingness of the findings discussed in this study to their own classroom context.

In Chapter Six, I discussed how the findings of this study could potentially be applied and modified to support the development of a coherent curriculum in contexts similar to the one studied in this research. Patton (2002) described this application as an extrapolation of the findings and explained that

> An *extrapolation* clearly connotes that one has gone beyond the narrow confines of the data to think about other applications of the findings. Extrapolations are modest speculations on the likely applicability of findings to other situations under similar, but not identical, conditions. Extrapolations are logical, thoughtful, case derived, and problem oriented rather than statistical and probabilistic. (p. 584)

The extrapolation lens for analysis considers the likelihood that findings are applicable not identical to a similar situation. It is impossible to find two classrooms of students that are exactly alike or two teachers' styles and delivery methods that are the same. Therefore, I did not expect that the findings of this study would transfer to all classrooms, but that the experiences of these four teachers would provide relevant information about developing a coherent curriculum that others could extrapolate from, and perhaps modify, to fit their own context.

As with any qualitative study, there is the possibility of personal bias influencing the data analysis process. With my previous experience and interest in teaching from an interdisciplinary perspective, it was normal that I should have bias about the topic of curriculum coherency. However, I followed the phenomenological process of bracketing my own views with journaling and talking on a regular basis with my advisor and the teacher participants. This process made me aware of my own views of designing a coherent curriculum. Thus, I consistently returned to the data when developing the assertions to ensure credibility.

Lastly, the triangulation of data collection methods played an important role in this study with regards to trustworthiness. "Triangulation has been generally considered a process of using multiple perceptions to clarify meaning, verifying the repeatability of an observation or interpretation" (Stake, 2000, p. 443). Because finding a perfectly repeatable observation or interpretation is highly unlikely, triangulation is a necessary part of qualitative research. Overall, the design of this study followed a triangulated approach, which included: a) collecting the experiences of the four teachers as a unit of study rather than as individuals and looking for patterns in the team's instructional approach, b) employing multiple forms of data collection, and c) using the research questions during data analysis as a means of comparing the data from the two sets of interviews and field observations (classroom and team meetings).

CHAPTER FOUR: SETTING THE STAGE

The purpose of this chapter is to provide a setting for the asserted findings presented in the following chapter. I present vignettes that offer a window into second grade at Drake Elementary in two sections: A Window into Their Teaching and A Window into Their Team Meetings. These vignettes paint a picture of the teachers' individual teaching and team collaboration. I constructed the vignettes from field notes taken during observations of class teaching and team planning sessions. I selected these particular pieces to represent the kinds of teaching and interactions I observed throughout my 10 weeks in second grade at Drake Elementary.

A Window into Second Grade at Drake Elementary

Each teacher described their teaching role as moving back and forth on a continuum of inquiry-based teaching depending on their students' needs. The first vignette in this section includes two examples of Brenda's teaching depicting the extreme ends of this continuum of inquiry-based teaching. I selected this portion of Brenda's teaching because it most clearly portrays the two types of teaching that Tracy, Heather and Brenda used in science. In addition, it is also representative of the whole team's approach to teaching across all subject areas.

The second vignette in this section is a combination of a reading/writing lesson that Nancy taught and a mathematics lesson that Tracy taught. I included these two lessons in this vignette for the purpose of describing the role that science played in connecting the curriculum.

A Window into Their Teaching

Vignette 1: Science Teaching

It is Tuesday, January 4, 2005 and the second day of the science unit called *Changes*. The students are sitting on the carpet and Brenda starts today's lesson with a demonstration of how to use a hand lens safely and effectively for observing. She points out the two types of magnification lenses, how to hold the lens to use each type of magnification, and how to move the lens to examine or move the object to examine. Some students practice with the hand lens in pairs while others practice alone. During this practice time, Brenda moves around to different students talking to them about what they are examining and what they are noticing about the item they are observing through the hand lens. She also takes time to remind students that they can either move the hand lens or the object for a clearer observation. Next, Brenda reviews the five senses and how to safely use them to observe and notice things in science.

The activity for this science class is a continuation from the previous lesson. The students are to continue working with an Alka-Seltzer tablet (a solid) and water (a liquid) and record their properties before and after they mix them together. Brenda instructs the students to follow the directions and complete the questions on the back of the handout from the last class.

After receiving their handouts, the students move from the carpet to their desks to work in pairs. They continue recording their observations of the tablet and water separately. During this time period, Brenda moves from table to table asking the students questions such as, "What words are you using to describe your solid?"

One student responds with, "It stinks and it is rough."

In an attempt to get the student to be more descriptive with her observations Brenda follows up by asking this student, "What do you mean by it stinks?"

Another student holds the tablet right up to her nose to smell and Brenda reminds the student about wafting to be safe. Brenda explains to the student that scientists do not hold things directly to their noses because some substances can be harmful and you can not always be sure if what you are smelling is safe or not. "It is a good habit to learn to waft when smelling anything." The student seems to have difficulty understanding how to waft so Brenda models this action for her and the student copies.

After a few more minutes of observing, the students share from their desks what they wrote for describing the tablet. Students use words such as: sticky, rough, like a strong mustard smell, looks fuzzy through the lens.

Next, Brenda calls the students back to the carpet to review how to observe and record characteristics of the liquid. She also explains to them that the hardest task for them, which is also the most important, is to not put the solid (the tablet) into the liquid until she tells them. The students return to their desks to continue completing question #2 on the handout, which involves observing the liquid and writing about its characteristics.

Once again, Brenda walks from table to table asking the students clarification types of questions. After a few minutes of observing the water, she asks the students to share the descriptive words they used to describe the liquid. After a few students share the characteristics they have written down, Brenda proceeds with the next step in the task. She says, "Now is the time when we are going to observe a change." She reviews the steps for putting the tablet into the water and the importance of immediately recording observations. With the students sitting at their tables, Brenda cues them at the same time to drop their Alka-Seltzer tablets into the glasses of water.

As soon as the tablet makes contact with the water, the students begin to “Ooh and ahh”, and the following conversation occurs:

One student says, “It looks like Sprite.”

Another says, “It’s bursting out.”

A third student says, “It’s fizzing.”

Brenda asks this third student, “What is fizzing?”

The student replies, “The tablet in the water.”

A few second later, a student shouts out to the rest of the class, “It’s gone.” Brenda follows-up asking, “What is gone?”

Collectively, several students reply, “The Alka-Seltzer.”

Brenda takes this opportunity to begin directing the students’ observations and thinking to the notion of changes and having them explain what they think is going on. She starts by asking, “Is there any evidence of the Alka-Seltzer left? A student replies, “Yeah, there are little white dots on the bottom of the glass, and I stuck my finger in so there are some on my finger, too.” Brenda then asks the students to consider how the Alka-Seltzer changed when it came into contact with the water. They would be discussing this idea together once everyone cleaned up and met back on the carpet.

With their handouts filled in, the students come to the carpet and Brenda initiates discussion, “What changed?” This gave several students the opportunity to share what they had observed changing during the investigation.

Brenda summarized the conversation with the following questions:

- So you would agree then that the solid changed?
- You would agree then that the water also changed?
- So are you saying that the solid dissolved in the liquid?

To push the students' thinking a little further Brenda asks, "What do you think would happen if we took an Alka-Seltzer and dropped just a small drop of water on it? She had demonstrated this earlier in the class when the students were making their separate observations about the tablet and the liquid. She walked from table group to table group doing this demonstration. A few students respond that she showed this to them and that from what they saw when she did this, as well as what they saw their own tablet do when hit the water, the Alka-Seltzer tablet fizzes when water touches it.

"So," Brenda continues, "considering what you know now, what do you think might happen to the tablet if you were to use a different kind of liquid – not water?" She encourages the students to turn knee-to-knee to discuss with a friend what they think would happen if a different liquid was used. The students share their thoughts about this scenario. "So I was wondering if I should bring in different liquids tomorrow for us to try with the Alka-Seltzer," Brenda muses. Most of the students respond enthusiastically, "YEAH!" They take the last few minutes of class to sketch out a plan for this extension activity.

Brenda concludes the lesson with two statements for the students to ponder: 1) keep noticing changes around you, and 2) look at how solids and liquids change when they come together.

Three weeks later Brenda's class is nearing the end of the *Changes* unit. Brenda begins today's science lesson with reviewing the chromatography investigation from the previous class. Four students share their stories of trying the chromatography technique at home over the weekend. One student used coffee filters with markers, pencils, and crayons. Another student used coffee filters with different colors of markers. A third student used paper towels and tried dropping the water with a straw, but said it was too messy because it was hard to control the water from coming out when he lifted his finger. The final student used a folded paper towel into a small square and polka dotted it with various colors.

After this sharing time, Brenda initiates a whole class conversation about possible "I-change" (or independent) variables that the students could change from the previous investigation to study in other investigations. Throughout this conversation, Brenda consistently asks students questions that require them to think of maintaining a fair test. The students are to elaborate on the chromatography investigation by developing their own question and considering how they will collect evidence to answer their question.

After the whole class discussion, Brenda tells the students to return their table groups to decide on which "I-change" variable they want to study. Before they leave for their tables, she reviews once more what an "I-change" variable means (i.e., only one item/variable changes). As the groups of students begin planning for their own chromatography investigation, Brenda moves from table to table asking them to consider what materials they would need to do their test.

After a few minutes of group planning, Brenda calls the students back to the carpet to give them an opportunity to share with others and receive feedback on their plans. She asks the students to report on what "I-change" variable they plan to test and what variables they are not changing in order to ensure they are conducting a fair test. At this point Brenda explains to the students that scientists do lots of planning, thinking and predicting before doing an investigation, just as they are doing.

Next Brenda discusses with the students different ways to record the evidence they will collect in their journals. This is a task that the students are familiar with. However, in previous lessons Brenda had guided most of the data collection ideas. This time she asks the students for their ideas and records them on the class whiteboard for them to refer back to once they are at their tables working in their groups.

After a few minutes Brenda brings the conversation to a close and dismisses the students back to their tables. As the students start talking in their groups about their ideas and refining any changes to the design of their investigation, Brenda passes out their journals. She then asks the students to take the next few minutes to record all their plans in their journals making sure to state their testing question, the materials they are going to need, the "I-Change" (independent) and the "keep the same" (dependent variables in their test, and their prediction of what they think will happen based on their experience from what they learned with the previous whole class chromatography investigation. She outlines these headings: question, materials, I-change and stay the same, and prediction on the board as a reminder for the students. She also includes this list: collected data, conclusions, and further questions. As she writes, she reminds the students to think about their conversation on the carpet and to decide as a group how they want to record the information they gather.

The students have the next 20 minutes to conduct their test and record their observations. Lunch time is fast approaching and the students run out of time to record all their observations. Aware of this problem, Brenda calls the students back to the carpet briefly and asks a few groups to share what they have observed so far. She concludes the lesson by explaining that they will begin the next science class with these investigations so everyone has enough time to record the data they need to answer their questions. They will also take a little more time to share results and how those results help to answer their inquiry question.

The students return to their desks to cleanup. Brenda gathers their journals and begins scanning a few of them. The students put their materials to the side of the room so they can easily retrieve them the time they meet for science.

Vignette 2: Teaching Other Subjects

A literacy lesson. It is Monday, March 14, 2005 and Nancy has all the students gather on the carpet for the literacy lesson. She begins the lesson by placing a piece of writing on an overhead projector and reading it aloud to the students. She asks the students to think about what the piece of writing is about, to listen to it, and enjoy it.

She prepares to read the same piece of writing a second time, but this time asks the students to look for some interesting characteristics of the writing – some "noticings" about the writing style. For example, a noticing may be that the piece is written like a poem.

At the end of the second reading, Nancy asks the students to share with everyone some of the noticings they made about writing style of the poem.

One student says that the word "rock" is repeated in the poem.

Nancy elaborates on this statement and asks the students a few more questions about what the repeating word or phrase style of this poem made them think of or made them feel.

After some discussion of why writers might choose to use repetition in their writing, Nancy goes on to explain to the students that in this lesson they are going to do some of their own poetry investigations. They are going to read several poetry books and mark poems with post-it notes that use a repetitive style.   She explains that she wants the students to work in partners. After finding and marking several repeating poems, they are to decide on their favorite poem to share with the class. They also need to be prepared to explain why they chose that particular poem.

Before sending the students off to do their poetry investigations, Nancy reviews the characteristics of a good poetry partnership that they have been working on in their peer reading sessions.

After about 15 minutes of paired reading, Nancy calls the students to the carpet to share their poem(s). They sit in a circle on the carpet and Nancy sits with them. Following each pair's sharing of their favorite repeating poem, Nancy asks the pair to explain why they chose that poem, what the repeating element was in the poem, and why they think the author chose to repeat those words. All the students in the circle have an opportunity to share and respond to these three questions. A few students comment throughout the sharing time when a classmate reads a poem that they also like.

Nancy ends this share period with a poem about worms that a student in the class wrote. The student explains that she repeated the word "worms" as a way of separating sections of her poem. The student also says, " the poem was about worms so I felt that this word would work best."

Nancy explains to the students that they are now going to have a chance to be poetry writers and create their own repeated poems. She says they can write a new poem or take an old one that they wrote and turn it into a repeated poem. As she distributes the students' poetry journals, she responds to some of the students' individual questions about the writing task.

As the students work independently on their poems, Nancy moves from table to table reading students' work over their shoulders. She stops periodically and sits down with a student at their table if she finds something she wants to ask more questions about or senses that the student needs a little more guidance. She often opens the conversation by asking, "I wonder what will happen if you…." The students continue writing until the end of the period.

A math lesson. It is Thursday, March 3, 2005 and Tracy has all her students gathered on the carpet to review a patterning strategy they have been working with the past few days. She begins with drawing a growing pattern of three cubed figures on the whiteboard (see Figure 1).

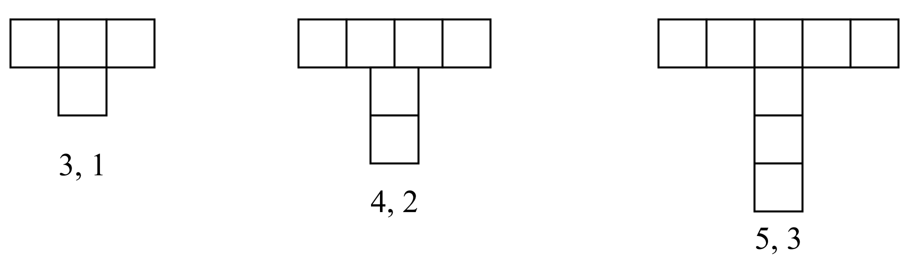

Figure 1. A copy of the growing pattern Tracy draws on the whiteboard.

Tracy asks the students to look at all three figures and to think about how the pattern is growing each time. She gets even more specific and tells the students to look at the row number and the column number for each figure. She then poses the question, "What do you notice?"

Two students give responses that do not appear to connect to Tracy's objective for the lesson, because she continues to ask the students to observe the three figures and to share more of their noticings. As this sharing session progresses, she probes the students' thinking with questions like,

- What difference do you notice between the row and column numbers?
- What are some other ways you could think of the figure that would help you explain the relationship between the two numbers?
- Is there an equation you could use to help us think about the relationship between the two numbers?

As the discussion continues Tracy often refers to the students as mathematicians and explains that the thinking they are doing about the pattern in these three figures is similar to how mathematicians think when they are trying to solve a problem – they consider multiple ideas and try them out.

Students share noticings such as: the first number increases by one each time and the second number also increases by one each time, there is always a difference of two between the two numbers, and the "t" shape is getting bigger each time. Tracy asks students to use their ideas to think about what the next figure would look like if the pattern was to keep growing. She suggests they turn to a neighbor and share their idea about what the next figure would look like in the series.

After a few minutes, Tracy calls their attention back to the board and asks if anyone wants to share their ideas with the class. Several students raise their hands and Tracy records each of their ideas on the board. After each volunteer or pair shares their idea, the class discusses the possibility of their idea working in the pattern. Following a fairly lengthy discussion, Tracy summarizes the different patterns the students have suggested and draws out the next figure according to the various student rules. The students begin discussing amongst themselves and begin to focus on one proposed rule that the pattern was +1 on the row and column number each time.

Tracy explains that they will continue to work on patterns, developing rules for the patterns and investigating patterns. However, for the remainder of their math period today they are going to go back to the topic of 2-digit subtraction that they have been doing the past few days. She explains that for the rest of today's class that they will be reviewing the strategy of using "friendly numbers" to solve a number sentence that includes the subtraction of two 2-digit numbers.

A Window into Team Meetings

Brenda, Tracy, Heather and Nancy met regularly twice a week for an hour during their shared planning time on Tuesday and Thursday afternoons. The following two vignettes illustrate a typical Tuesday and Thursday meetings. They illustrate the role of each member and the kinds of conversations one could expect to hear during these meetings.

Vignette 3: Tuesday Afternoon

It is 2:30 and the second grade teachers are gathered in Nancy's classroom at her small group meeting table. They have their planning binders laid out in front of them and they are looking over what they have scheduled for the week.

Brenda initiates conversation with the question, "So tell me what you have been doing with writing?" Nancy is the first to respond, saying that she used the read-aloud book they have been discussing in class to look at the detailed style of writing the author used.

This team had participated in a book study the previous year that looked at Lucy McCormick Calkins' and Abby Oxenhorn's book "Small Moments: Personal Narrative Writing" (2003). Each teacher was using the strategies from this book with their students. For example, their students select something they do in their daily life and write about that event. The goal is to have the students to go from a broad discussion of the daily event to a narrowed and detailed description of a brief moment within the event.

Nancy directs the conversation to publishing. For this piece of writing she wants the students to focus most of their time on revision writing rather than rushing to illustrate. So she is considering having her students complete a page that is folded in thirds instead a full booklet. She believes this will make the students focus on writing concisely and will leave less blank room. Heather says that she likes that idea because she was also thinking of making the illustrations more of a side item in order to keep the students' focus on improving their writing. However, she was thinking of having her students publish their small moment into a small booklet instead. Brenda says she is still in the brainstorming phase of writing with her students and that they have not really caught on to the significance of the detailed writing that is needed to go from a broad concept to a small moment. She has not yet thought about how they are going to publish their writing but asked to see some examples from Heather's and Nancy's students when they are finished.

As everyone else talks and shares their ideas Tracy writes in her planning binder on this week's schedule. She takes advantage of a brief pause in the conversation to say to her colleagues that she is having similar difficulties as Brenda and that she feels better knowing she is not alone. She too wants to place less emphasis on illustrations and have the students focus more on the publication of their writing. She asks Nancy and Heather if she can photocopy the booklet formats they are considering using with their students to help her think about what she might want her students to do.

They all take a moment to write some notes down on their weekly plans. During this time the conversation starts to go off topic from planning their writing lessons to stories about their students. But Brenda quickly brings them back on task by asking Nancy, "So what are you going to do again in writing tomorrow?" Brenda asks Heather the same question and Heather looks back and forth between Tracy and Brenda as she explains how she is helping her students to move their small moments revisions forward.

Nancy interjects with a question about the writing prompt assessment that they need to give their students next week. Tracy suggests doing it on Monday so they can get it over with at the beginning of the week and not have it interfere with the rest of their week. Brenda, Heather and Nancy all agree that this is a good idea. They block off the writing period for the assessment that day.

Tracy has to leave to pick her students up from the counselor. Nancy, Brenda and Heather stay for another 20 minutes to talk about some other lessons the have used since last Thursday and how they plan on building from those lessons for the remainder of this week.

Next the teachers start talking about the strategies they are working on with their students during "Making Words." This is equivalent to spelling time in traditional classrooms. These teachers pull words from the content areas that follow similar spelling patterns and that students frequently encounter in their reading, writing, and speech. Heather shares a lesson where she used the story "Bubbles Popping" as a word study about combinations of long "a" sounds. She says that she selected this book because it discussed a lot of the same ideas that the students were experiencing in their science unit. In particular she described an activity with an Alka-Seltzer tablet where the students observed different ways to dissolve the tablet at different rates. She explains that the book reinforced some ideas about dissolving while also introducing students to a more extensive vocabulary they can use when recording evidence in their science journals.

This connection between science and reading leads the teachers into a conversation about predictions. They share with each other different strategies that they are using in science to help the students develop predictions. They want to extend this beyond science and find ways to help their students become more comfortable with taking risks in making predictions in other content areas as well (e.g., reading response journals and math discussions). After a few minutes of sharing different techniques that each of them use, they pause to write some ideas down in their planning binders.

Heather asks Brenda how her science class went that morning because she remembered from their last meeting that she was having some difficulties getting her students to develop questions. Heather asks, "Did they ask any questions? I am thinking I want to do the guided inquiry on Thursday prior to the ice experiment because my kids have started asking some interesting questions and I think they ready to begin a more inquiry approach." Brenda explains that her students' questions are starting to get better, but that she ran out of time to ask them about their questions so they will not be ready for a guided inquiry on Thursday. Heather says she might go ahead and start a guided inquiry with them on Thursday anyway, rather than doing the next lesson in the *Changes* unit.

At 3:20pm they start to wrap things up because Brenda, Nancy and Heather have to go pick up their students from the specialists and get them ready to for dismissal at 3:45pm. They each make some last minute notes in their planning binders. On their way out of the room, they discuss different materials that they would like to borrow from each other for the remainder of this week.

Vignette 4: Thursday Afternoon

It is 2:40pm and once again the four second grade teachers are gathered in Nancy's classroom around a small group discussion table. The conversation begins with Brenda saying that she is planning on doing her writing prompt preparation with her students tomorrow for their assessment on Monday. Nancy chimes in, saying that they started some of this preparation today. She describes to the team the mini-lesson that she did with their students. Brenda then asks Heather what she did in writing today, Heather explains that she started some prompt writing today, but she is going to focus more on it tomorrow.

Tracy directs the conversation back to the small moment writing that they were doing at the beginning o f the week. She explains that she has not had a chance to start this writing with her students. She is having difficulties getting her students to think from the broad concept to the more narrowed topic of a small moment. She has been thinking about how the others are approaching this writing style and that she is going to take a slightly different approach next week. For example, Nancy had her students focus on the sequence of writing what occurs in a small moment, but Tracy does not want to separate the show and tell part of the writing from the sequencing because this may be where some of the problems are coming from. She wants to try incorporating both sequencing and show and tell writing together.

After a brief pause, Tracy changes the topic from writing to math. She explains to the others that she wants to start working with some of the ideas from Chris Confer's book "Math by All Means: Geometry, Grades 1-2" (1994) to supplement the district's text. Tracy says she really likes the hold and fold activity that Confer suggests because it helps to develop students' math vocabulary. Brenda says that one of her favorite activities is "Rocket Discovery" because it deals with shapes within a shape. Tracy concurs. Heather and Nancy like the idea of using this book. They suggest some other books that they could connect the literacy and math pieces. One of them raises the idea of using the book "Cloak for the Dreamer" (Friedman, 1995) because of the discussion about shapes in the cloak design. The math planning conversation ends with talk about using ideas from Confer's book to decorate their classroom bulletin boards with a geometry theme.

While everyone takes a moment to write in their planners, Tracy changes the topic to science. She initiates this discussion with an explanation that the *Changes* unit they have been studying in science is meshing well with their reading she is having her students look for changes in story lines.

Brenda reminds Tracy to save the water from the ice melting activity from the *Changes* unit to use for the evaporation activity next week. Tracy responds, "O.K. Are you planning on moving forward with some discussion on the water cycle for a couple of days next week?" Brenda replies that she thinks they will take all of next week to cover the water cycle.

Brenda, Tracy and Heather discuss different book they can use to connect to the water cycle ideas they are going to be studying in science. Tracy says that she wants to begin her reading with fictional books that have elements of the water cycle in them. As they progress with their study of the water cycle in science, she will draw connections between the stories and the science concepts.

At this point all four teachers examine their reading books and begin to brainstorm how they can connect the books with the remainder of the *Changes* unit. They find a couple of books that focus on character change. They talk for a few moments about how the idea of character change could be incorporated into reading and the small moments writing. This conversation carries on for about 10 minutes, until one of them realizes it is 3:30pm. They quickly pack up and go their separate ways to pick up their students to get ready for school dismissal at 3:45pm.

Closing the Window

The purpose of this chapter was to provide a window into the community of practice of the second grade teachers at Drake Elementary. These four vignettes provide only a brief glimpse into what I observed, but I believe they paint a clear picture of their approach. In the next chapter I present the assertions grounded in the data to address the research questions. I refer back to the vignettes in this chapter to provide context and support for these claims.

CHAPTER FIVE: FINDINGS

The research questions organize the findings for this study. I begin with a discussion of the teachers' views of science followed by an explanation of their approach to teaching science. In the third section, which combines research questions two and three, I examine the role that science played in the curriculum design and implementation of other subjects. In the final section I highlight features of team planning sessions in order to illustrate the role that these meetings had in maintaining their curricular approach. I used patterns that emerged over the course of data analysis to form the assertions that address the research questions. Following each assertion, I provide evidence from the teachers' interviews, observations, and vignettes presented in the previous chapter.

Teachers' Views of Science

Science as a Tool for Motivation

All four teachers viewed science as a tool to motivate their students to learn. Brenda explained that science was a tool they used to excite their students about reading and writing. On a more personal note she shared that,

> The most exciting thing about [science for me] is that it is a way for kids to shine. By shine I mean, there is a lot of pressure put on our kids to make sure they read and write on grade level. In science you don't have to be a scientist on grade level. (Brenda, Interview 1)

Heather's perspective further elaborated on the idea of science as tool for motivating student learning. She stated that, "The interest and enthusiasm from the kids [in science] is tremendous. Those kids we can't hook in because they can't read or write will give more and try more through their interest in the science we were teaching" (Heather, Interview 1). This need for finding a hook to motivate students to read and write was a concern that all four teachers expressed. They agreed that their science curriculum provided a natural connection to non-fiction reading and writing, which initiated the hook they were looking for.

Science Makes the Connection

Tracy explained that, in the 2-3 years prior to this study, the emphasis in education had shifted from developing conceptual understanding and critical thinking skills to solely focusing on the traditional 3 R's of reading, writing, and mathematics. Nancy described this shift occurring as a result of the enforcement of educational reform polices such as No Child Left Behind.

Regardless of these external forces, these four teachers continue to view science as a natural fit with their instructional goal of preparing their students to be critical thinkers. In their opinion science provides the necessary contextual experiences for students to develop their reading, writing, and mathematics skills. The following quote from Heather illustrates this view of science.

> I think science helps to connect all the subjects. It is involved in everything we are doing whether we are reading a book; there are science concepts in so many of the things we were reading. It is involved with the math and helping our kids to relate to some of the math concepts through something we've done in science or something that is around us in our world. So science is involved in it all. (Heather, Interview 1)

In addition to providing students with a context in which to improve their reading, writing and mathematics skills, the teachers also view the role of science in the elementary curriculum as providing students with necessary learning experiences. As Brenda stated (Interview 1) when the students are learning science they are "[using] everyday materials, asking questions about what, why or how something that they see on a daily basis works."

Throughout their interviews, the teachers also explained some students' prior knowledge was limited and as a result they can sometimes struggle with using contextual cues to recognize words when reading. They believed that elementary science was important for broadening students' foundation of prior knowledge in order to provide them with the means necessary to connect their learning for deeper conceptual understanding. This view was expressed in the following quote.

> We know background knowledge influences the difficulty of the text one can read, [therefore] if I want my students to understand what a cumulus cloud is then I need to talk about it with them, they need to see them, compare and contrast [cumulus clouds] to other clouds… [Only] then are students going to recognize it and comprehend the word should they come across it in their reading. (Tracy, Interview 1)

Science as Inquiry

This teaching team used what they called an inquiry-based approach to teaching science. For example, Tracy (Interview 1) explained that "When designing a science curriculum it needs to include an inquiry approach, meaning you investigate then discuss. Learning comes from the investigation rather than the investigation reinforcing the learning." From my analysis of the other teachers' interviews, I found that Tracy's colleagues echoed her view of designing science from an inquiry approach. But more importantly, from my observations of Tracy, Brenda and Heather science teaching I noticed that they also practiced this view. For example, the first vignette in the previous chapter showed Brenda modeling the notion of explore first and explain second. During both the Alka-Seltzer and chromatography lessons the students were encouraged to ask questions and devise a plan to investigate the phenomenon before they came together as a class to discuss what happened. This allowed the students to gain background knowledge about the phenomenon with which they could then draw from to develop some explanations and plausible answers to their questions. This idea of explore before explain was a significant component of their approach to classroom inquiry.

Teachers' Meaning of Inquiry

While the term inquiry can sometimes mean different things to different people, I found that this teaching team had similar views of what constitutes inquiry-based teaching. In the following quotes each teacher describes what they think inquiry instruction looks like.

> I think [inquiry] really is looking at the kids' questions in conjunction with what we are doing and then setting up a question that could be solved; especially in the beginning with the kids…I really think that on a second grade level it is looking at the questions the kids are answering and trying to set-up some kind of fair test where they know about the "I – change variable" or the independent variable, and the dependent variables and they build an experiment with help – with support from me – to create their experiment and then share out. I mean I think that is really important part that they have a chance not only to conduct the experiment but to share out and find out what other questions they still have, and what things they noticed. I think they really feel like scientists as they do that. (Brenda, Interview 2)

> I think inquiry is taking some of the children's ideas and investigating them. Whether it is in reading, where they are taking some ideas and questions they have, or we have as a group, and they are exploring. They begin during inquiry to take ownership of it and they change it somewhat and it may not be the ideas that I was really starting with, or the idea that I may have been hitting upon and trying to focus on, but it builds from what we began with. They're starting to take that responsibility for what they are studying and what they are questioning and thinking about, [inquiry] allows them the freedom to do that. (Heather, Interview 2)

> [Inquiry] is definitely an investigation. You are opening up and just looking at the different aspects of something. We do that as writers and as readers and as mathematicians in the classroom all the time. When we open a new area of writing it is time for kids to explore and to look at it and to notice things about that genre and then we look at them more

> closely and say O.K. so how can we use this as a writer to help us. (Nancy, Interview 2)

> For me as a teacher, inquiry means structuring my delivery so that children have the opportunity to explore and discover and then define. From the students' perspective I think it means taking an active role in my learning - not just sitting there listening to somebody tell me all the information, but I actually have to do something to get the information. (Tracy, Interview 2)

These quotes not only clarify how these teachers identify with the term inquiry, but they describe what inquiry-based instruction looks in science (see Brenda's quote) as well as other content areas (see Nancy's quote).

Summary

This teaching team viewed the teaching of science as serving two purposes. First, science acted as a tool to motivate students to read and write. The teachers' believed that science has the ability to motivate students because it draws on their natural curiosity of the world around them. Secondly, science provided the necessary contextual experiences to develop a foundation of knowledge for the students to draw from to connect their learning to their own experiences and to what they see in the world around them. The students often come across concepts when reading or in their everyday life that they had studied in science class. Having first questioned and explored in science class about why or how a phenomenon worked, the students developed a knowledge base from which to draw upon when they come across it in another context.

In addition to science serving a distinct purpose in their curriculum, this team saw inquiry as an approach they used to teach science. Because of their expertise and background, each teacher viewed the definition of inquiry through a slightly different lens. Regardless of whether they were defining inquiry through a science lens, a literacy lens, a student's lens, or a teacher's lens, there were three common themes that emerged from their meanings of inquiry: 1) teaching through inquiry is a way for students to develop their questioning, investigation, and critical thinking skills; 2) inquiry is not just for science; the basic principles of inquiry serves an instructional approach that can be applied to the teaching of all content areas; 3) along a continuum of inquiry-based practice a teacher's role shifts from directing the students' investigation to collaborating with the students in designing an inquiry. These four teachers explained that this shift in roles occur gradually over time as the students' understanding and abilities to do inquiry improve and they begin to take a more active role in their learning. The teachers' views of inquiry-based science teaching and the shift in teacher and student roles are elaborated on in the next section.

Teachers' Approach to Teaching Science

Students' Role in Inquiry

Within their meanings of inquiry both Brenda and Tracy discussed how inquiry was a student-centered approach because the direction of the curriculum was driven by the students' questions. I observed this emphasis on student-generated questioning throughout my 10 weeks at Drake Elementary (see Chapter Four, Vignette 1). The basis of the chromatography lesson was to give students the opportunity to extend their thinking about the previous chromatography lesson as they planned an investigation in small groups. Each group had the responsibility of developing a question to investigate as well as their method for investigating their question.

Heather noted that the student-centered focus of inquiry-based instruction encouraged her students to take greater ownership of their learning. Her students were involved throughout the entire learning process, from asking the question to developing an explanation based on the evidence they gathered. The inquiry approach afforded her the opportunity to extend the students learning beyond the set curriculum. This allowed her to not only "meet the needs of the kids, but also meet the needs of the curriculum" (Heather, Interview 2).

Teachers' Role in Inquiry

The second theme discussed within the teachers' meanings of inquiry was the role of the teacher. Tracy (Interview 2) explained, "Inquiry means structuring my delivery so that children have the opportunity to explore and discover and then define." As a result of restructuring her delivery, Tracy's students were not passively absorbing information; rather they were actively engaged in all phases of their learning.

The teachers viewed their role as multi-faceted when teaching from an inquiry perspective. When first introducing their students to inquiry, the teachers modeled the process for their students. Modeling involved the teachers asking the question to investigate, the teacher organizing how to record the information in the students' journals, and the teacher walking the students through the procedures of the investigation. During the first few weeks that I observed of the *Changes* unit I noticed Brenda, Heather and Tracy doing this type of modeling for their students (see Vignette 1).

Eventually the students grew comfortable with asking follow-up investigation questions and collaborating with the teacher to design the procedures for their investigations. Thus, the teachers' role in teaching science shifted from that of modeling an inquiry approach to supporting the students to design and implement their own inquiry-based investigations. This shift resulted in less teacher direction and more student input, meaning the teacher was transitioning from a guided approach to inquiry to a more open approach to classroom inquiry.

Vignette 1 illustrates the differences between the teachers guiding the students through an inquiry process at the start and facilitating them to develop their own open inquiry later. The Alka-Seltzer lesson models the guided inquiry approach and the chromatography lesson demonstrates the teachers' open inquiry approach.

According to Brenda, the objective of Alka-Seltzer lesson was for the teacher to show the students how to set up a fair testing situation. This required a teacher-directed emphasis on the difference between independent and dependent variables. She guided her students through this inquiry in the sense that she provided the question they would investigate, and a handout that walked them through the steps of the investigation. In addition, throughout the exploration portion of the lesson, she probed students' thinking with questions such as, "What words are you using to describe your solid?" and "What do you mean by it stinks?" These kinds of questions pushed the students to be more descriptive in their data collection efforts.

Towards the end of the lesson, Brenda guided the students' thinking about the changes that occurred when the Alka-Seltzer came into contact with water. After giving all the groups an opportunity to report on what happened when the tablet was dropped in the water, Brenda guided the students toward an explanation with a summary of their previous conversation. To do accomplish this task she asked the students a set of three summative questions: (1) So you would agree then that the solid changed? (2) You would agree then that the water also changed? (3) So are you saying that the solid dissolved in the liquid?

The final indication that Brenda guided her students' inquiry experience in this lesson was at the end when she asked the students to talk with each other about what they thought would happen to the tablet if a different kind liquid was used. Ending the lesson in this way allowed Brenda to model for her students how an inquiry-based investigation naturally facilitates the development of more questions. This Alka-Seltzer lesson demonstrated Brenda's use of a guided approach to classroom inquiry.

The second portion of Vignette 1 illustrates an open inquiry approach, in which case the teacher takes on a more collaborative role in designing the investigation with her students. According to Brenda, the objective of the chromatography lesson was for the students to demonstrate their understanding of how to setup a fair testing situation. Therefore, instead of modeling how to design and implement an inquiry-based investigation for the students, she expected them to take more ownership of their learning and work within their groups to develop their own research question and methods for investigation.

The students in Tracy's and Heather's classes experienced a similar shift from guided to open inquiry throughout the four weeks of the *Changes* unit in which the Alka-Seltzer and chromatography activities were included. Over the course of the *Changes,* unit the teachers asked the students questions that would probe their thinking further and would require them to refine their abilities to do inquiry.

In each class the teachers started by walking through the various steps of an inquiry-based investigation; over time they slowly relinquished their authority of designing the investigations to their students. At the end of the unit, students collaborated in small groups, generating their own research questions, organizing their own methods for data collection, and drawing conclusions based on their evidence. They discussed with their classmates and produced some plausible explanations about the phenomenon they were investigating.

The Use of a Common Teaching Model

I observed the teachers employ a common structure to their science lessons which typically involved students in explorations before explanation. This structure was similar to Karplus and Thier's learning cycle model (Abraham, 2003) but included five phases instead of three. Bybee and his colleagues at Biological Science Curriculum Study (BSCS) adapted the learning cycle to include five phases and named it the "5E instructional model" (Trowbridge, Bybee, & Carlson-Powell, 2004). In their instructional model the five phases are: Engage, Explore, Explain, Elaborate, and Evaluate.

The following is a description of how each phase of the BSCS 5E model was demonstrated in the science classes I observed: (a) teachers *Engaged* the students about a concept and asked them questions to assess their prior knowledge; (b) teachers provided their students with an opportunity to *Explore* about the concept they were studying and often encouraged this exploration with a variety of materials; (c) teachers gathered the students for a community discussion where the students were expected to share the evidence they collected during their exploration phase and use the information to collaborate with their classmates to formulate a possible *Explanation* about the concept; (d) the students would then have an opportunity to *Elaborate* on their explanations with further explorations of the topic, resulting in the cyclical effect of the model.

The fifth E of the BSCS model stands for *Evaluate*. Although this is an important component of any lesson, it was not typically how these teachers concluded their lessons. Instead, they used various forms of assessment (e.g., journals, informal conversations, class presentations) and embedded them throughout the lesson. Not only did embedded assessment provide them with information about their students' conceptual understandings, but it also helped the teachers to know when to transition to different phases in their instruction.

To illustrate how the teachers employed the phases of their 5E model to inquiry I selected portions of the Alka-Seltzer lesson described in Vignette 1 and organized them according to the 5E headings (see Table 4). I did not include the Evaluate phase in this chart because this phase was threaded throughout the lesson. In this lesson, Brenda focused on formative assessment strategies such as questioning the students as they were performing the tasks. The information she received from the students' responses indicated when the students needed reminding about a technique (e.g., how to properly waft), or questioning students' descriptions of what they observed to make sure they were providing enough details (e.g., what is meant by "stinky" or "fizzing").

In the final portion of this lesson, Brenda posed questions to the students to engage them in thinking about what they observed in that lesson and to consider other possible investigations about mixing solids and liquids. In this lesson, Brenda proposed the elaboration idea with her line of questioning. Over the course of the *Changes* unit and students gradually took more responsibility in designing the extension investigations. Only when this transition in ownership occurred did the teachers assess the students' summative understanding of the science concepts and procedures for designing a fair test

Table 4

Identifying Four Phases of the 5E Model in Brenda's Alka-Seltzer Lesson

5E Phase	Recognizing the Beginning of Each Phase
Engage	Brenda starts today's lesson with a demonstration of how to use a hand lens safely and effectively for observing. She points out the two types of magnification lenses, how to hold the lens to use each type of magnification, and how to move the lens to examine or move the object to examine. Some students practice with the hand lens in pairs while others alone. During this practice time, Brenda moves around to different kids talking to them about what they were examining and what they are noticing about the item they are observing through the hand lens. … (p. 74)
Explore	The activity for this science class is a continuation from the previous lesson. The students are to continue working with working with an Alka-Seltzer tablet (a solid) and water (a liquid) and record their properties before and after they mixing them together. … (p. 74)
Explain	Brenda takes this opportunity to begin directing the students' observations and thinking to the notion of changes and having them explain what they think is going on. She starts by asking, "Is there any evidence of the Alka-Seltzer left? ... (p. 76)
Elaborate	To push the students thinking a little further Brenda asks, "What do you think would happen then if we took an Alka-Seltzer and dropped just a small drop of water on it? ... (p. 77)

test (e.g., requiring the students to record all the steps of their investigation in their journals – see the chromatography lesson in Vignette 1).

Summary

In their classroom, students explored a phenomenon before they were asked to explain the phenomenon. Teachers explained that their approach to inquiry-based teaching supported the development of students' process skills such as questioning, gathering evidence, discussing with others, and extending investigations with further questioning. The Alka-Seltzer activity discussed in Vignette 1 showed how Brenda used the process skills as a means of guiding the students through an inquiry-based investigation. She accomplished this by providing a structured outline for the students to follow. This required them to develop their observation and questioning skills, gather data, use the data to make explanations, and communicate what occurred in both written and oral forms. However, between the Alka-Seltzer activity to the chromatography activity, the leadership role shifted from Brenda modeling to the students how to design a science investigation in the Alka-Seltzer activity, to the students' showing Brenda how they plan to investigate their own questions in the chromatography activity.

The teachers viewed an inquiry approach as student-centered. The students' role in this approach was to be actively engaged in learning and to take more ownership of their investigations. Meanwhile, the teacher's role during an inquiry changed according to the needs of the students. At times the teachers modeled how to inquire about a topic using a guided approach to inquiry; other times they facilitated open inquiry where the design and implementation of the investigation was the students' responsibility.

This shift in the teacher and student roles occurred because of the team's use of a common learning cycle instructional model – the 5E instructional model (Trowbridge, et al., 2004). The teachers did not define their instruction as following this model. However, after numerous observations of their science lessons, I found that their lessons typically followed the stages of the model and I appropriated the term to describe their teaching.

Throughout the six weeks of observing Brenda, Heather, and Tracy teaching science, I could identify when they transitioned between the stages of the 5Elearning cycle. When using the learning cycle instructional model, these teachers required their students to use their prior knowledge of a concept to support their observations of phenomenon, to test different situations, to ask questions, and make predictions about what might occur if a certain variable in the experiment was to change. For Brenda, Heather, and Tracy inquiry-based science lessons revolved around this type of learning cycle.

The next section describes how the teachers' perceptions of inquiry-based science and their use of a 5E learning cycle instructional model flowed over into their teaching of other subjects.

The Role of Science in Planning and Teaching Other Subjects

Similar to their science teaching, the team structured their lessons using an adapted 5E model of instruction. Also, in reading, writing and mathematics much of the learning was focused on developing students' process skills in context and guiding their learning with exploration followed by explanation.

Science Provides a Common Instructional Model

While I frequently observed the 5E model of instruction during science I also saw the teachers applying this model to their teaching of other subjects. For example in both Nancy's and Tracy's lessons described in Vignette 2: Teaching of Other Subjects, the pattern of engage, explore, explain, and elaborate were used. See Table 5 for an illustration of how these four phases also fit with Nancy's poetry lesson.

Similar to Brenda's Alka-Seltzer lesson, Nancy incorporated opportunities to formatively assess the students while they explored repetitive poems and shared their

Table 5

Identifying Four Phases of the 5E Model in Nancy's Poetry Lesson

5E Phase	Recognizing the Beginning of Each Phase
Engage	[Nancy] begins the session by placing a piece of writing on an overhead projector and reads it aloud to the students. She asks the students to just think about what the piece of writing is about, and to listen to it, and enjoy it. ... (p. 80)
Explore	After some discussion on why writers might choose to use of repetition in their writing, Nancy goes onto explain to the students that today they are going to do some of their own poetry investigations. They are going to read through several poetry books and mark poems with post-it notes that use a repetitive style. … (p. 81)
Explain	After about 15 minutes of paired reading time the teacher calls the students back to the carpet to share their poem(s). They sit in a circle on the carpet and Nancy sits with the students in the circle. Following each pair's sharing of their favorite repeating poem Nancy asks the pair to explain why they chose that poem, what the repeating element was in the poem, and why they think the author chose to repeat those words. …(p. 81)
Elaborate	[The next task transitions a reading investigation into a writing opportunity.] Nancy explains to the students that they are now going to have a chance to be poetry writers and create their own repeated poems. …(p. 81)

findings with their classmates. While Nancy's choice of an elaboration activity could have also been used as an assessment task, she told me afterwards that the purpose of the writing exercise was to introduce the students to writing this style of poetry for themselves. She did not plan to assess the poems they wrote that day as final published pieces; rather she would review the students' poems to further inform her own teaching about the next step she needed to take on this style of writing.

Science Provides a Common Link

These four teachers described science as the driving force for planning their curriculum. They believed that science was "intertwined" or "connected" to all other subjects. This relationship between science and the other disciplines was expressed in the following quote.

> I would be really sad if my kids were only thinking about one right answer to any problem, whether it is science or reading or whatever. I love listening to them retell a story or you know talk comprehension and they know that it is not just a one word answer that I am looking for. And I think it is because of the science and how we do the science, where we are looking for multiple solutions that helps guide us [to do this]. (Brenda, Interview 2)

Brenda suggested that without science, students would not have the foundation they needed to excel in other subject areas. This quote demonstrates how the inquiry-based approach that this team used with science influenced their approach to teaching of all other subject areas.

To echo this belief Tracy (Interview 2) stated, "You really can learn about science through the other disciplines and you can learn about the other disciplines through science." Tracy was describing the commonality between disciplines as the way in which we learn, meaning the process skills that are common to all disciplines. The following conversation between Tracy and me (Interview 2) provides a clearer picture of what Tracy was referring to with her notion that process skills span across the disciplines. She does not say that process skills are the same in all disciplines; rather they are similar and teachers tweak the process skills to fit the context of each discipline.

> Tracy - We predict as scientists and we use – those are exactly the same. I use my prior knowledge – what I know – and I make a guess. Well when I am reading and I come across a word I don't know I am going to use all my prior knowledge from the passage that I am reading and beginning

> sound to make a logical prediction and then I am going to check myself, I am going to continue to read and say well now I am going to gather more data or information – does what I just said make sense – if it doesn't I am going to go back and reread and fix you know my original prediction or make a new one. And do the same thing when I am experimenting, I am going to make a prediction and then I am going to do some things – I am going to gather data, and then I am going to go back to that original though and say, "Um was that original though accurate or not accurate?" So it looks different…
>
> Interviewer – Depending on the context you are using it in?
>
> Tracy – Right, but I think the thought processes are the same.

Brenda's thoughts about how to teach science supported Tracy's. With regards to how science connects to other subject areas Brenda (Interview 2) stated,

> You know I think there is a really nice connection for the children. Looking at books to supplement what they are doing, using their science journals to write things down, you have the art component as they are drawing and labeling what they are noticing in a way that they use their logic and the problem-solving. They are thinking of questions and making those connections. I think if you try to do science in isolation yes you can do it, but then it becomes one activity linked to another activity. It's the connection across the other subjects that really go in-depth for the kids.

Brenda drew attention to the common link between the skills used in science and those in other disciplines. What I found interesting was that neither teacher mentioned the need for content connections. Instead they focused the idea of going deeper with student learning and building their critical thinking skills as a result of emphasizing the process skills connections across the disciplines.

Heather's comments about the connections between science and the other subjects differed slightly from her two science teaching teammates. Unlike Tracy and Brenda, Heather explained that science concepts can be found in everything around us. Studying science provided her students with a foundation on which they could build. The following quote from Heather (Interview 2) supports this view.

> I think science helps to connect all the subjects. It is involved in everything we are doing whether we are reading a book; you know there are science concepts in so many of the things we were reading. It is involved with the math and helping our kids to relate to some of the math concepts through something we've done in science or something that is around us in our world. So science is involved in it all.

Nancy combined all of her teammate's views. She expressed the same thoughts as Heather about science providing a foundation of concepts for students to draw upon when reading and writing, and she also spoke about the common use of the process skills across the disciplines.

> I think that [science] is intertwined into all subjects because you can read non-fiction and if science is in there and you can write non-fiction. But even beyond non-fiction, there are lots of stories out there that you need to have some scientific information to understand. In class the kids are asked to use their senses and to notice things carefully as a writer, and those are a lot of the same things they are asked to do in science. They have to watch, they have to look, and they have to think about and use their senses and come up with why they think something is happening. In math there are a lot of the same correlations. They have to be able to take information and use it to show what they've learned or explain what information they've gathered. [These are skills they use] in both science and math. (Nancy, Interview 2)

According to these teachers, science served a dual purpose in their classroom. First, process skills such as making observations, asking questions, and making predictions were acknowledged as a common link across disciplines. Tracy, Brenda and Nancy all spoke about students using these same skills in science, reading, writing, and mathematics but modifying them to fit the need of each discipline. Heather described the second common link between science and the other disciplines as the sharing of conceptual understanding. Heather explained that the concepts students learn in science support their learning in other subjects because they provide a context for student learning. Nancy acknowledged this idea.

Process Skills as the Common Denominator

These teachers used the process skills associated with inquiry-based science instruction as the blueprint for connecting their curriculum, thus making their curriculum *interdisciplinary* in nature (Drake, 1993; Drake & Burns, 2004). The process skills they referred to were similar to those described by Harlen (2001): observe, question, hypothesize, predict, plan and carry out investigations, interpret or infer information, and communicate. The teachers did not introduce the term hypothesis at this grade level because in the past they found that second graders had difficulties distinguishing between hypothesizing and predicting. However, all of the other process skills that Harlen mentioned were a regular part of the teachers' and students' everyday classroom practice.

Emphasizing the process skills associated with an inquiry-based curriculum was a natural part of these teachers' practice. Nancy explained that

> [students] have to do a lot of the same things in inquiry no matter what subject area it is. You are asking them to come up with an idea and to notice and to be a careful observer of things. So whenever they're looking at something then they are going to do that across the board no matter what subject area it is. They are going to be careful, they're going to look at it, they're going to think about it and they're going to know that they can form an opinion about it and come up with the characteristics of whatever you want them to.

Teachers viewed the science process skills as a way to connect the subjects. They believed that using the process skills as a framework for learning would encourage their students to think more deeply and critically. Brenda explained how the process skill of questioning supported students' critical thinking abilities.

> Thinking of questions, looking at our parameters for investigating the question, coming up with a potential solution, and not being [satisfied] with that one solution, but instead [using that information to] propel yourselves to think of the next question. (Brenda, Interview 2)

This teaching team placed a strong emphasis on questioning throughout the curriculum. More specifically, they focused on students developing the questions. As Brenda (Interview 1) explained,

> It is the questioning that really gives ownership and makes [the learning] meaningful for the kids. When you just have a set of really good activities and no questioning by the students I don't think they go as deep with their thinking.

For these teachers the process skill of questioning was a key component of their inquiry-based approach. Besides the plethora of questions I observed the teachers use throughout their teaching, some of which were included in Vignettes 1 and 2, the teachers frequently spoke of questioning as a critical component to their teaching. The following quote illustrates this claim and demonstrates how the teachers used questions to guide their students' explorations across all subject areas.

> As readers and writers when we want to learn about an author's technique we go about that through inquiry. We say, O.K. lets study the things that Kevin Henkes does as a writer, those are the great things that we want to do, what does he do? So we throw out the Kevin Henkes books, we read them and we highlight all the things that we say, "Oh wow, and he did it here, and he did it here, and he did it here. Well what is that thing? ...Oh well he uses repeated line." So that structure of asking a question, now let's research it, let's make some discoveries, kind of goes across the curriculum; it is more of an overall teaching approach. (Tracy, Interview 2)

The strategy of question, explore, and explain was an integral part of the teachers' inquiry approach. The process skills of questioning, observing, interpreting, and communicating all played a significant role in this approach.

In addition to developing their students questioning skills, the teachers agreed that in second grade there needed to be a strong emphasis on improving students' observation skills. Heather (Interview 2) elaborated on this idea:

> For where we are, we talk a lot about observation skills because for the [students] that is very important and that's something they need to get better at and to work on. So we really talk a lot about using our senses and observing, because measuring is always interesting with them at this point. So we talk a lot at this point about just observing and what do they notice and trying to make some predictions and gather some ideas and information through their observations, and then having them think about why did it happen and talk about their ideas and questions for further testing.

According to Heather, improving students' observation skills was important because it led to their use of other process skills, such as predicting, interpreting what happened, communicating their ideas and developing questions for further study. These teachers did not view the process skills as separate entities, but instead considered them to be an interrelated core of skills necessary for learning in all disciplines.

Implementation of Common Process Skills

Although the process skills provided the common link across subject areas, the language associated with these skills also supported the implementation of the teachers' vision for a connected curriculum. The teachers' consistent use of the terminology associated with the process skills established a framework for connecting the curriculum. I observed that the students also started to use the same process skills terms in their own talk. Nancy explained that, regardless of the fact that she did not teach science, she still believed using the process skills language was important to her own teaching. As she stated, "Words like noticing, make an observation, those kinds of things go across the board, so it is important that I am also being consistent with my verbiage" (Nancy, Interview 2).

Because the process skills indicated the similar actions in science, mathematics, and literacy, eventually the names of each skill acted as cues for the students in their learning. Because the teachers were consistent with using this language in their daily instruction, the students rarely needed to consult with the teachers about what was expected of them. Instead the students started to show more independence in designing and completing their own inquiry-based tasks.

To further illustrate this strategy of a common language, I compiled various instances from my field notes representing when I heard the teachers use process skills language with their students in order to get them to perform a certain task (see Table 6).

Regardless of how the teachers referred to a process skill in a content area, the students applied the skill similarly for each discipline. For example, when the students were asked to make a prediction, regardless of whether it was in science, mathematics, or reading/writing they understood that this meant that they needed to draw from their prior experiences and knowledge to suggest or estimate what would happen next in the investigation or story.

In addition to hearing the teachers repeated use of process skills language, I also noticed towards the last few weeks of my observations that the students began using some of the same language (e.g., I notice…, I wonder…, I predict…, what would happen if…). With this transfer of language from teachers to students, the teachers recognized

Table 6

An Overview of the Process Skills Across the Curriculum

Process Skills	Science	Mathematics	Reading/Writing
Questioning/ Wondering	Facilitated students' organization of an investigation or extended their thinking for another.	Used to challenge students' mathematical thinking of other strategies.	Guided students' examination of an author's technique or particular features of a character in a story.
Predicting	Required students to draw from their prior experiences to consider what may happen during an investigation	Students' may estimate an outcome prior to calculating the answer.	Involved students using details from a story to suggest the next sequence of events in the plot or with a character.
Observing/ Noticing	Students looked for evidence related to their investigation to record.	Students looked for patterns in number sequences to improve addition strategies.	Students looked for examples of writing techniques in books that they could use to edit and improve their own writing.
Inferring/ Concluding	Students used evidence to produce plausible explanation(s) for the investigated question.	Examined a 100's chart to deduce patterns and test these patterns beyond 100.	Discussed how a character's actions affected the plot or how descriptive writing improved a story.
Communicating/ Sharing	Students reported explanations and discussed alternative ideas and/or additional inquires.	Students described methods they used for solving a problem and justified their choices.	Students shared details from a story as evidence to answer a question or they shared a piece of their revised writing.

Note. Names of process skills adapted from Harlen, W. (Ed.), 2001, (pp. 4-5).

that students were able to state connections between disciplines. For example, Heather noticed this occurring when she overheard her students saying things like, "Oh that's like when we studied this," or "You know, that is kind of like when we did this activity."

> When they were doing the "Human Body" unit, and we were talking about different inquiries that we could do the kids said, "Well we can do that one

> because we've done one [similar to it] when we did the *Changes* unit." So they see those connections and that's nice that they are able to see those connections [because] that means that some of it stuck with them and they got it. (Heather, Interview 2)

With this new development came a change in the classroom teacher's role.

> Students would make the connections from what they were doing in Math and Science to their reading and writing. The students would make the connections without me having to explicitly describe the connections. When the students can verbalize these connections themselves then the teacher just becomes one of the members of the conversation rather than a director. So, I learned from them, which is awesome. (Heather, Interview 1)

According to the teachers, the key to students making connections across the curriculum was their recognition of how the process skills were used in all disciplines. The teachers' consistent use of the process skills language acted as cues for the students to reach this realization.

Summary

Based on my observations, I surmised that this team accomplished an inquiry-based approach to designing and implementing a coherent curriculum in three ways: 1) they used a learning cycle approach similar to a 5E instructional model to guide their teaching of all disciplines, 2) they employed the process skills associated with scientific inquiry as the common link across disciplines in order to establish a rational learning strategy for their students, and 3) they threaded the language of the process skills throughout all of the disciplines so students would recognize the language and start to make their own connections for learning.

Considering these three methods for developing a coherent curriculum, I determined that science acted as the driving force for this team's curriculum. It was the team's views of inquiry-based teaching, which mainly stemmed from their knowledge of how to teach science, which influenced their overall curriculum design and implementation.

Role of Team Planning

Considering the phenomenological framework for this study, I wanted to learn from the teachers the role they believed their regular team planning sessions played in assisting them with their approach to designing and implementing a connected curriculum. Each of the teachers believed that team collaboration was a necessary component of teaching, but they acknowledged that not all teachers practiced it, nor was the idea always supported within a school community. Heather explained that a major reason why the teachers at Drake Elementary continued to collaborate with one another was because of the support the principal provided. This support included such things as organizing the teaching team's preparation periods so they coincided and offering to fund substitute teachers through the school's professional development fund so classroom teachers could take half days off together to consult about curriculum and student learning issues.

Several years before this study, when Drake Elementary staff considered Drake to be a Basic School, regular team planning meetings occurred for both vertical (mixed grade levels) and horizontal (same grade level) teams. According to Drake's principal, with changes in education reform (e.g., NCLB) and the school district's attention redirected to the need for improving elementary students' mathematics and literacy scores on state tests, significant changes were made to how schools in the district organized their curriculum.

For example, with an emphasis on improving mathematics and literacy scores came an increase in the amount of time classroom teachers were required to spend on these two content areas. This resulted in a significant decrease in time the teachers had to spend on the other subject areas (e.g., science, social studies, and arts). A reduction in classroom minutes for art, music, physical education resulted in a reduction in time available for teachers to plan together because those classes taught by specialists allowed classroom teachers their planning time . However, even with these district level changes, the second grade teachers at Drake continued to use the little common planning time they were given because as Brenda (Interview 1) said, "Planning together is just a part of our team; we are kind of obsessed about it actually."

For these teachers, regular team planning sessions were a necessary part of their teaching practice because (a) they believed the benefits of team planning outweighed the time spent, (b) each of them was committed to the idea that teachers need to be continually involved in professional development and for them the bi-weekly team meetings was one way of ensuring continuous professional growth, and (c) they valued the unique skills each member contributed to the group and as a result felt their teaching was stronger as a collective unit rather than individually. The remainder of this section elaborates on these three findings.

Benefits

For some teachers having only a couple of planning periods a week is not enough time to do all they have to do, so using the little planning time that they have to meet with other teachers may seem counter productive. However, the members of this teaching team said just the opposite. For example, Tracy (Interview 1) explained that "without the team our approach to team would look very different, because I would be responsible for pulling everything together myself." Tracy seemed to suggest that the team approach actually saved her time and helped her to implement the inquiry-based curriculum she felt fit her teaching philosophy. The team meetings were not a burden on these teachers' time, but the most efficient way for them to gather new ideas and resources for their teaching.

Besides the time factor, these teachers described the support they give each other as another benefit of their twice weekly team planning sessions. They described the purpose of the planning sessions as a constant check-in for them to make sure that they were staying true to their curriculum, meeting their objectives, and addressing the needs of their students. According to Brenda, having the opportunity to meet regularly with her grade level colleagues ensured that she was reflective in her teaching practice.

> It is very beneficial whenever you can sit down together and brainstorm and figure out – O.K., this is working but this is not working out. Ask each other "Did this happen to you when you were doing this?" "Think about trying this whenever you are doing this lesson." Just having the time to talk things out is important. (Brenda, Interview 1)

In addition to encouraging reflection on their practice, the regular meeting times gave teachers the support they needed to take risks in their teaching and refine their ideas before putting them into practice. Heather commented on this when she said, "Having the team support allows you to try different things and take risks in our teaching. If you are alone you want to feel safe and secure, so instead of branching off with different ideas you may resort back to the manual more often." Brenda (Interview 1) noted, "Teachers get better at teaching when they work as a team. Learning goes up when you are asking questions, talking and problem-solving with others."

In summary, these teachers felt that their weekly Tuesday and Thursday meetings provided them with benefits that they could not get on their own. The meetings encouraged them to be reflective about their teaching practice, they provided an outlet to talk through problems and share strategies that worked, and increased their accessibility to resources (e.g., materials and teaching ideas). Overall, these teachers viewed their time together as a benefit rather than a detriment to their teaching practice.

Commitment to Professional Development

When I spoke with the principal of Drake Elementary, I asked her about what she thought made the team of second grade teachers approach teaching differently than other teachers in her school. She replied,

> The second grade teachers are probably the team that uses the philosophy "We can" more than any other grade level, a far as they are a very positive group of professionals. They are extremely talented – there is a national board certified teacher on that team, so that they know deeply about how children learn and they know what an effective classroom looks like. There is a former mentor teacher on that team, a former Title 1 teacher; it is just a really rich team. They are highly, highly trained, highly qualified teachers without a doubt. So you are going to study the Masters I guess is what I am saying in that respect. (Principal, Interview)

This dedication to professional growth was something that was evident throughout team meetings. There were several times throughout the 10 week period that I was at Drake Elementary that I heard these teachers refer to strategies they had read about in a professional book study or workshop they had attended. For example, in Vignette 3, the team used writing strategies described in the Calkins and Oxenhorn book (2003) "Small Moments: Personal Narrative Writing" when they were planning for their next writing lesson. All four teachers were familiar with this book because they had studied it in their school's professional book club the previous year. The principal explained that participation in book clubs was voluntary, but often all four members of the second grade team took part because it was a part. This reflected their nature as professionals.

For these teachers, professional development was an integral part of their teaching practice. According to both Tracy and Brenda, it was important for all teachers to think of their own learning as much as their students'. For example, Tracy (Interview 2) said, "Teachers need to read and [see themselves] as a researcher. I think you have to be out there reading the latest thing related to your field and what it is you want to do." Brenda (Interview 2) concurred with this idea as she noted,

> I think that it is really helpful [for teachers] if [they] are doing some kind of, not necessarily course work, but something where [they] are reading, and have a group of people that [they] can talk with. For me it was course work because that is what I love, but you know a book study or something like that [also works].

For these teachers, the time they spent together was just another form of professional development. The twice weekly meetings gave them the opportunity to gather ideas and resources just as in any other professional development program outside of their school. Because of their like-minded commitment to professional development, they viewed each other as professional resources for their teaching.

Contributions

As the newest member of the team, Nancy described the collaborative atmosphere of the second grade teachers as a vital part of her success in returning to the classroom after several years as a reading specialist. Nancy acknowledged that, "Without this team I'd be struggling more and would feel isolated. I wouldn't be as reflective with my teaching nor would I be as willing to experiment with different teaching practices." She went to say, “This team is rare. We are well matched with respect to skills, we value each others strengths, and our personalities get along; we live each other professional and personally” (Nancy, Interview 1).

I asked each teacher to describe her contribution to the team. In each case they identified a different attribute. However, each of them explained that the reason they valued their planning time together was not because of what they offered but because of what they gained. As Brenda (Interview 1) noted, “Just having the time to sit with three other experts that will help me plan things out is invaluable.”

Because of the respect they showed for each others’ expertise, I asked them to describe the contributions they felt each of their teammates offered. I learned that each person plays a specific role on the team. For example, Brenda’s teammates described her as a manager, because she often initiated the discussion at the team meetings, kept the conversation on task, and was the first to provide suggestions when a teammate had an instructional question or problem. Tracy was identified as the person who made curricular connections across the content areas. Yet similar to Brenda, she often would initiate the team’s conversation with questions. Serving a slightly different role, Heather was acknowledged as the organizer of the group, because she often took notes about their discussions and reminded them of special dates they needed to mark in their calendars (e.g., test dates and Grandparents Day). Under Heather’s title as organizer, she was also a resource person for different lesson ideas, especially those that integrated the disciplines. Nancy’s expertise was undoubtedly her experience as a Title 1 Reading Specialist. Therefore, Brenda, Tracy, and Heather all agreed that since science and mathematics were their strengths, Nancy's literacy background was a much-welcomed addition to the team.

Looking back at Vignettes 3 and 4, one can see why these teachers identified each other with those particular characteristics. For example, in both vignettes Brenda initiated the conversation and managed the conversation to ensure that everyone had an opportunity to share what they were doing, ask questions, or simply comment on someone else's story. From time to time she also took responsibility for bringing the conversation back on task. This was illustrated in Vignette 3 (see p. 86) when the team started to go off task about planning their writing and Brenda redirected the conversation with a question to Nancy. Brenda asked, "So what are you going to do again in writing tomorrow?"

Tracy's role as curriculum connector was illustrated in Vignette 4 (see p. 89) when she shared the connection between idea of changes they were studying in science and how she was having her students look for changes in storylines in reading. In this case, Tracy drew from two different experiences to share with her teammates how her students were grasping the concept of change because of the connections she made in both disciplines.

Throughout Vignettes 3 and 4, Heather's role as team organizer focused more on her position as resource. For example, in Vignette 3, Heather shared a lesson with her teammates in which she used the book "Bubbles Popping" (see p. 87). Throughout her description of this lesson, she explained how she used that book to connect to experiences the students had with the Alka-Seltzer activity in science, as well as how students used the vocabulary from that story in their science journals. A little later on in Vignette 4, Heather's organization skills were revealed once again when she referred back to a previous meeting and asked Brenda if her students were starting to develop any of their own inquiry questions. This question served two purposes for Heather: 1) she wanted to check back in with Brenda to see how she was progressing with her students, and 2) Heather planned ahead for her own lessons and wondered about division of materials with Brenda's and Tracy's classes.

Not only did Nancy's teammates view her expertise in literacy as a valuable contribution to the team, but Nancy explained that it gave her a different perspective with which to consider how an inquiry-based approach to teaching meshed with disciplines other than science. She said,

> Because I am not a scientist when I think of inquiry I see it through the lens as a reader or a writer. I see the same [inquiry] skills used in science in literacy, but I look at it from a writer's perspective. So for example with poetry, what does inquiry look like in poetry? So bringing out a question for the [students] and then having them go investigate what things they are noticing as a writer. Then having them come back and collaborate and talk about it as a group, what things they are noticing and sharing these…So I guess my perspective is a little bit different. (Nancy, Interview 2)

Because of this different perspective, most of Nancy's participation during the team meetings involved asking questions. Also, since she did not teach the science curriculum, she focused much of her discussion on reading, writing, and mathematics. She contributed to the geometry discussion in Vignette 4 (see p. 89) when she and Heather suggested using the book "Cloak for a Dreamer" in reading at the same time they were doing the geometry unit in mathematics.

I observed these teachers portray consistent roles throughout the 10 weeks that I visited their team meetings. When they discussed classroom and curriculum issues, Brenda usually initiated the conversation, Tracy made curricular connections, Heather came organized to share stories and resources, and Nancy probed her teammates for their ideas and suggestions, as well as offered her assistance with literacy connections. Although their time together was informal and fun, it was also productive because each member came to the table prepared to ask questions and share ideas.

Summary

For this team of teachers, team planning was not a requirement mandated from the outside; they deemed it necessary for successful implementation of their inquiry-based approach to a connected and coherent curriculum. They viewed second grade at Drake Elementary School not as four separate classrooms, but as a single unit which they facilitated as a teaching team. Their team approach served an important role in their instructional approach and offered several benefits to their teaching practice. Their community was defined by their individual contributions to the team's collaborative practice and by each member's commitment to professional development.

CHAPTER SIX: CONCLUSIONS AND IMPLICATIONS

The purpose for studying this case of 2nd-grade teachers was to examine how the teachers taught science and how their approach to teaching science impacted their teaching of other subjects. Four research questions guided both data analysis and write-up. These questions were: 1) How do these teachers view and teach science? 2) What role does science have in designing their curriculum? 3) How do they apply their approach for teaching science to their teaching of other subjects? 4) What is the role of team planning?

This chapter includes a summary of the findings, a description of the teachers' model for designing and implementing a coherent curriculum, a discussion of the findings in relation to the research literature discussed in Chapter Two, and an explanation of how this study contributes to the bodies of literature on elementary science education and curriculum coherency. I conclude with implications for elementary science education, teacher education, and professional development and suggestions for future research.

Summary of Findings

The first research question explored how this team viewed and taught science. Science provided a foundation for planning their curriculum. Their view of how science should be taught mirrored Schwab's (1962) description of *science as enquiry.* They used a learning cycle strategy to structure their science lessons and emphasized the process skills of scientific inquiry throughout their science lessons.

Based on my classroom observations and interviews with the teachers, I assert that the teachers' understanding of inquiry-based practice provided a framework for teaching their overall curriculum. According to the Brenda, Heather, and Tracy, their perspective of what inquiry is developed as a result of their understanding of effective science teaching. Although Nancy did not teach science, she claimed it was not difficult for her to understand and implement many of the same inquiry-based practices as her colleagues because of her work with Lucy Calkins research on children's literacy. Nancy explained that much of Calkins' strategies for improving students' reading and writing skills paralleled her teammate's views of inquiry-based science.

The teachers' inquiry-based approach to science teaching was woven throughout all the subject areas I observed. Their approach emphasized the development of common process skills across all disciplines and the use of a learning cycle strategy to guide their teaching practice. Both the inquiry-based learning cycle strategy and the emphasis on the process skills associated with scientific inquiry provided these teachers with the tools they needed to make curricular connections *visible and explicit* for their students (Beane, 1995); thus a coherent curriculum.

The teachers' regular team planning sessions played an important role in designing and implementing their model of curriculum coherency. Each teacher played a specific role in their community. During their interviews they acknowledged that it was the expertise of each member that contributed to the effectiveness of their community. The teachers described the benefits of their community as providing them with the confidence to take risks in their teaching. They appreciated the support given to each other and the opportunity for continuous reflection on their teaching.

Science played a significant role in these teachers understanding of inquiry-based teaching. Their notion of science classroom inquiry was the driving force for their curriculum. Therefore, based on the findings from this case study I posit that the elementary science curriculum has the potential to provide teachers with the tools they need to achieve a coherent curriculum across subjects.

A Model for Designing and Implementing a Coherent Curriculum

Based on the findings described above, I developed a model to represent how the teachers' achieved their vision of curriculum coherency (see Figure 2). The model draws from the findings for the four research questions to illustrate how this team planned and implemented their coherent curriculum. The purpose of this model is to answer the overall research question: How does a team of second grade teachers teach science and how does this influence how they teach other subjects?

The core of the model begins with the teachers' views of science and how they taught science. They view inquiry-based science teaching as including two components: 1) a learning outcome that includes both science content knowledge and science process skills knowledge, and 2) an approach to teaching that affords students the opportunity to ask questions, explore those questions, discuss their findings in an attempt to develop an explanation for their question, and then test or apply their explanation to a similar situation. Together the process skills and the learning cycle strategy were tools that the teachers *threaded* throughout their science curriculum (Fogarty, 1993).

The scientific process skills associated with the abilities necessary to do inquiry (NRC, 1996) was one tool the teachers used to make curricular connections and design a coherent curriculum. For example, to develop students' prediction skills the teachers had the students practice using those skills in all content areas; the only difference was the content they were studying. To further support the application of the process skills

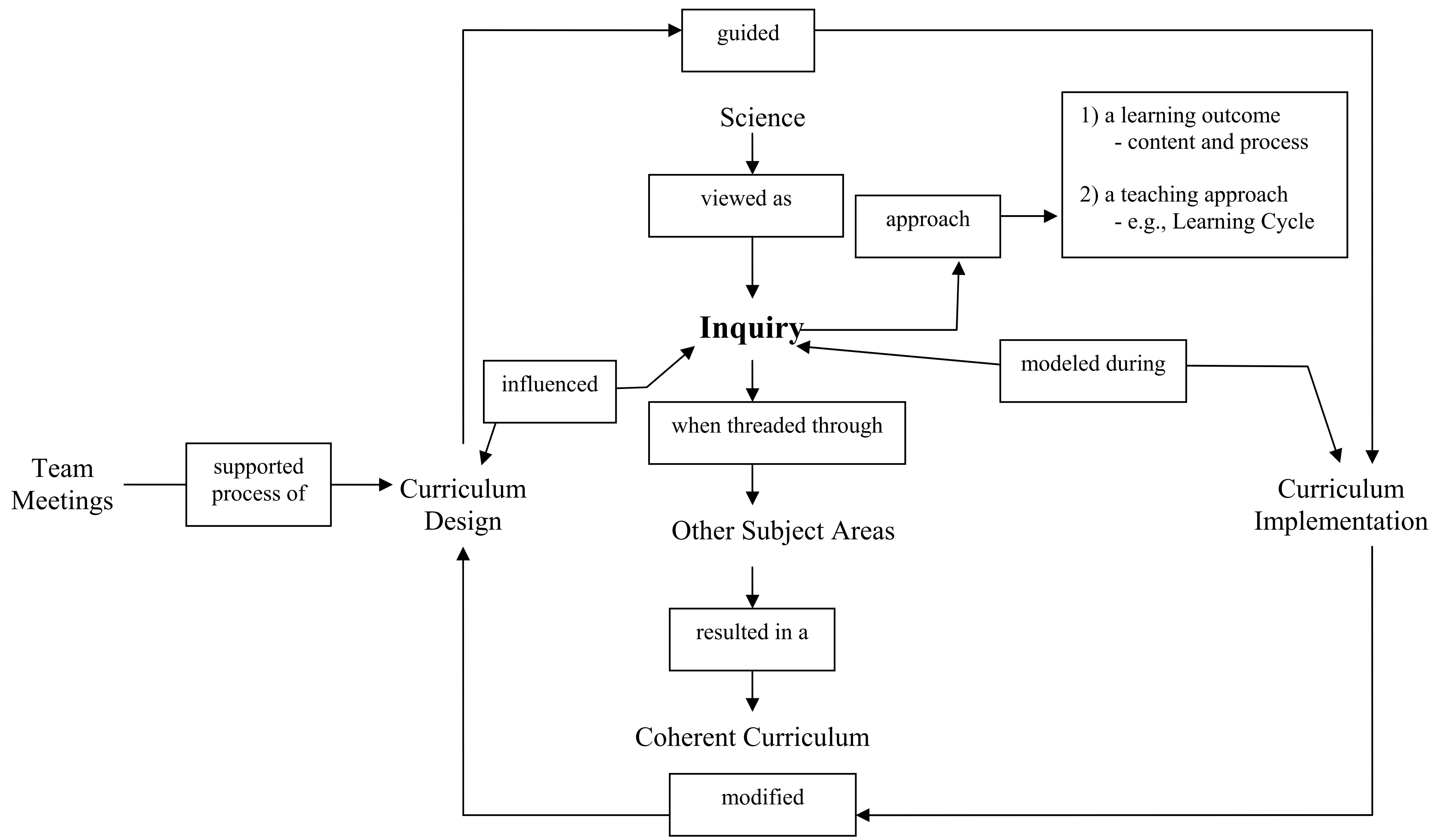

Figure 2. A model of coherent curriculum. This figure illustrates how the team of 2nd grade teachers in this study designed and implemented a coherent curriculum based on their views of inquiry. Their team meetings played a critical role in facilitating this model.

across the curriculum, the teachers referred to the process skills by the same name in each subject. Students knew, for example, that the method they used to make a prediction in science was the same method they needed to use to make predictions in mathematics, reading, and writing.

Harlen (2001) described the use of process skills as common elements to children's learning across all disciplines. The teachers' consistent use and language of the process skills across the curriculum ensured the connections were made explicit to the students. This provided clarity and continuity for the students' learning and as a result they started to make the connections for themselves. During my 10 weeks in the teachers' classrooms, I observed the students' vocabulary of the process skills language develop to the point that it became a common part of their everyday language.

The second tool the teachers used to develop a coherent curriculum was their approach to teaching science. They employed a learning cycle strategy similar to the BSCS 5E model of instruction (Trowbridge et al., 2004) to design and implement their curriculum in all content areas. This approach established the use of a common instructional model across the curriculum as well as across the four classrooms. Because the teachers held similar views about how to teach using a learning cycle approach, I often felt like I was observing one classroom rather than four separate classrooms. This strategy also supported Nancy's students when they left her classroom to join either Brenda's, Tracy's, or Heather's class for science. The consistent use of the learning cycle approach across all subject areas meant the students did not need to adapt to a different style of teaching.

The basic tenets of a learning cycle approach naturally support a process skills approach to teaching across the curriculum. Table 7 shows how the three purposes of the learning cycle (SCIS, 1970), from which the BSCS 5E model was developed, align with the use of specific process skills. Some processes overlap because students' thinking incorporates multiple skills as they move through the cycle.

Table 7

Aligning Process Skills to the Purposes of the Learning Cycle

Purposes of the Learning Cycle	Process Skills Engaged
1. Students provided with concrete experiences and given time to observe and reflect on the experience.	Observing; Raising questions; Interpreting information obtained; Communicating
2. Assisting students with concept formation.	Raising questions; Hypothesizing; Interpreting information obtained; Communicating
3. Students evaluating their understanding of the concept by applying it to another situation.	Observing; Raising questions, Predicting; Planning and carrying out investigations; Interpreting information obtained; Communicating

Influencing the teachers' model for developing a coherent curriculum was the role of the team meetings and their impact on curriculum design and implementation. Vignettes 3 and 4 described how the twice-weekly team meetings played a significant role in both the design and implementation of this model. The meetings provided the teachers with an opportunity to discuss new ideas, share resources, reflect on previous lessons, and provide a check-in to ensure they were staying true to their curricular objectives.

Although the teachers' views of inquiry influenced their curricular design, their design methods also influenced their approach to inquiry. As shown in Figure 2 the relationship between design and implementation is circular. In other words, one feeds off of another. For this teaching team, inquiry was at the core of this synergistic relationship.

The teachers' use of a learning cycle approach to teach science provided a structure for learning which the students became accustomed. Therefore, as the teachers shifted their role from modeler to facilitator, the students developed the knowledge of how to carry out investigations on their own. This knowledge motivated them to take more ownership for their learning.

This idea of the teachers' and students' roles moving along a continuum is similar to the description in the *National Science Education Standards* (NRC, 1996) of how to incorporate the essential features of scientific inquiry into a classroom (see Appendix I) along a continuum with from guided to open inquiry. The teachers' emphasis on the process skills and the learning cycle strategy made this shift from guided to open inquiry possible. The two lessons described in Vignette 1 demonstrated how the teachers' and students' roles changed as this shift occurred.

Discussion

The research questions for this study guided data analysis and assisted with the organization of the findings. The following discussion also is organized according to the research questions. I use the research literature reviewed in Chapter Two as a point of comparison with the findings of this study in order to understand how the findings from this study help to fill in the gaps in the literature, or at the very least, provide a different perspective.

Teachers' Views and Teaching of Science

Similar to the teacher described by Abell and Roth (1992), Brenda, Tracy and Heather could be labeled as science enthusiasts. Although they have modified their science teaching practice since their days as a *Basic School* (Boyer, 1995a), science continued to play an important role in their daily teaching. Therefore, unlike claims by Collins (1997), Raizen and Michelsohn (1994) and Roden (2000), that science is a second-class subject in most elementary classrooms, this team viewed science as important for their students' overall learning as literacy and mathematics.

External constraints. Like many elementary science teachers, this team also felt external constraints to teaching science such as time, resources, and state and district achievement requirements. However, the teachers in this study believed that their team approach to teaching helped them to overcome the constraints. During their planning meetings, they discussed what activities they were doing each day, decided when they would need certain equipment from the science kits, and arranged to borrow resources (e.g., books) from each other. This team recognized time and policy constraints as obstacles, but did not allow them to dictate how they planned their teaching.

Many teachers feel constrained by lack of support from administration or fellow teachers (Abell & Roth, 1992). For Brenda, Tracy, Heather and Tracy, this was not an issue. As Heather explained, having a principal who was a former teacher at Drake Elementary was helpful because she had gone through the same Basic School training as Brenda, Tracy, and Heather. Therefore, the principal held the same core beliefs as the 2nd-grade teachers about planning a coherent curriculum. To support the teachers at Drake with achieving a vision of curriculum coherency, the principal scheduled common planning time for each grade level, and should a teaching team request it, provided additional funds for larger blocks of team planning time.

Personal constraints. One theme repeated throughout the research in elementary science is teachers' lack of knowledge of how to transfer their constructivist views into practice. Beck and colleagues (2000) found that the teachers in their study believed in constructivist teaching practices, but rarely enacted them because of external constraints (e.g., lack of preparation time and limited resources). Researchers claim this is because they did not observe this kind of teaching when they were students (Fetter et al., 2002; Laplante, 1997).

Bryan (2003) found that Barbara, a prospective elementary teacher, had contradictory nested beliefs about teaching science. When asked to describe how she taught, Brenda's comments represented a teacher-directed practice, where the student's role is to listen and recall information and knowledge is transmitted from teacher to student. However, when asked to explain her vision of practice for teaching science she described her role as a facilitator that guides students' learning with questions, encourages students to explore, and designs a learning environment where knowledge is transmitted from activity to student. Therefore, Brenda's teaching practice was influenced by a traditional set of teaching beliefs, but her vision for teaching was influenced by a reform-based set of teaching beliefs.

Barbara's struggle between these two nests of beliefs is not uncommon (Tobin et al., 1990; Levitt, 2001; King et al., 2001). The teachers in this study did not appear to have this same internal conflict. As Nancy explained, the professional collaboration opportunities she had with Brenda, Tracy, and Heather were valuable to her growth as a teacher. She stated, "Without this team I'd be struggling more and would feel isolated. I wouldn't be as reflective with my teaching nor would I be as willing to experiment with different teaching practices" (Interview 1). Nancy's teammates expressed similar views about the value of their team planning.

Role of Science in this Team's Curriculum Design

Science provided this team with the foundation for planning their curriculum. The process skills of scientific inquiry and the learning cycle approach acted as tools for the teachers to plan their science teaching. The process skills outlined by Harlen (2001) were the core of the goals these teachers held for their students' science learning. The teachers introduced the students to inquiry by first modeling when and how to use certain skills in science (refer to Vignette 1). Over time, as the students began to develop their observation, data gathering, explanation, and communication skills, the teachers' role shifted from a modeler of inquiry to a facilitator. The teachers explained that this shift in their teaching occurred as the students started to take on more responsibility for their learning and began to question and inquire on their own.

This shift in responsibility was supported by the use of a learning cycle instructional model. The learning cycle has been noted in the research as "an effective instructional strategy with many advantages over more traditional approaches in terms of students attitudes, motivation, process learning and concept learning" (Abraham, 2003, p. 520). Brenda, Tracy, Heather and Tracy's comments about science motivating their students to read and write provides additional support for this claim.

Abraham and Renner (1986) and Renner et al. (1988) concluded that the order of a learning cycle matters in the sense that students need to experience a phenomenon before generating an explanation for the phenomenon. Brenda, Tracy and Heather followed a similar *explore before explain* procedure when teaching science. It was this process that provided a consistent structure for the students learning and helped to design guided inquiry experiences. The lessons described in Vignettes 1 and 2 illustrated this approach and it was compared further in Chapter Five with the comparison of those lessons to the 5E model (Trowbridge et al., 2004) of a learning cycle approach (see Tables 4 and 5).

Applying an Inquiry-based Approach to the Teaching of Other Subjects

This team's use of a learning cycle strategy went beyond their teaching of science and extended across all content areas. The process skills of scientific inquiry acted as the *thread* that weaved through all disciplines (Fogarty, 1993) and provided *visible and explicit* connections for the students (Beane, 1995).

Many researchers describe the commonalities between science and literacy (Akerson & Flanigan, 2000; Baker & Saul, 1994; Casteel & Isom, 1994; Century et al., 2002; Gaskins & Guthrie, 1994; Glynn & Muth, 1994; Rodriquez & Bethel, 1983). Castell and Isom (1994) described the relationship between science and literacy as synergistic; the 2nd-grade teachers in this study had a similar view. The team often commented that science provided a context for students to practice reading and writing, but reading and writing provided them with the tools necessary to learn science content. Therefore, this team did not view science as competing for time with other disciplines as described by other researchers (Collins, 1997; Raizen & Michelsohn, 1994; Roden, 2000). Instead, they viewed the process skills of inquiry as a way to offer a coherent and balanced curriculum for their students.

Science and mathematics instruction also showed evidence of a synergistic relationship in this study. This team explained that the data collection and analysis procedures in science often required their students to use mathematical tools and calculation strategies. Some researchers caution that not all mathematics can be taught through science; only some mathematical concepts that can be learned through scientific investigations (Kirst et al., 1997).

In response to this concern, Lehman (1994) asked both preservice and practicing teachers if they believed the integration of science and mathematics was doable and if so, was it happening in schools. All participants agreed that math/science integration was doable, but few said it was actually happening in their schools. It is important to note that Lehman's study was conducted with secondary teachers, so it may be possible that if the same question was asked to elementary teachers the results would be different. Nevertheless, most teachers in Lehman's study experienced science and mathematics as separate disciplines and the majority of teachers taught using a fragmented lens for curriculum design (Fogarty, 1993), similar to how they experienced it as students.

The team of teachers in this study did not hold the same fragmented view of curriculum, but did believe in the need to keep the integrity of the disciplines intact. At no time did they suggest the blurring the boundaries of the disciplines. Rather they advocated the integration of constructivist learning strategies across the disciplines.

While there is some research on the use of a learning cycle strategy in teaching science (Abraham & Renner, 1986; Renner et al., 1988; Settlage, 2000), I found no specific use of a learning cycle strategy in teaching other disciplines. Considering the call in all standards documents to make curricular connections, a learning cycle approach like this team used could prove to be helpful in meeting the call for a coherent curriculum.

Role of Team Planning

Within this study I referred to the team's interaction as professional collaboration. The research framework that informs this finding is Wenger's (1998) notion of communities of practice (CoP). Wenger's description of a CoP was comprised of four components: community, meaning, practice, and identity. For the purpose of this study I do not discuss all these aspects of CoP. Instead I have chosen to elaborate on the elements of this teaching team's practice and how generate meaning within their community. These two components most closely relate to the findings of this case study.

First, I focus on Wenger's description of practice in a CoP. Wenger stated that as "we interact with each other and with the world and we tune our relations with each other and with the world accordingly. In other words, we learn" (p. 45). Wenger explained that a CoP cannot withstand time if it is solely developed because a job requires it. Brenda, Tracy, Heather, and Nancy came together to learn from one another, and therefore formed their own CoP. For them teaching was not only a way to earn a living, but a passion. It was this team's sense of passion for teaching that constituted their community of practice.

The teachers' concept of practice was an experience that included both explicit and tacit meaning. Their views of how to design inquiry-based lessons was something they explicitly discussed at their twice weekly meetings, but their shared view of what constitutes inquiry-based instruction was implied within their community of practice.

Wenger (1998) stated, “Practice is about meaning as an experience of everyday life” (p. 52). To elaborate on this statement he argued that 1) meaning is located in a process called the *negotiation of meaning*, and 2) this negotiation involves the interaction of two processes called *participation* and *reification*, which form a duality fundamental to the nature of practice. The teachers in this study were engaged in the process of negotiating meaning each time they met, whether it was during their scheduled team meetings or impromptu conversations over lunch. Throughout any given school day, these teachers were faced with various questions or problems requiring a negotiation of meaning based on both the explicit and tacit understandings of their CoP.

Wenger’s second argument about participation and reification looked at the process of how a CoP negotiates meaning. He described participation as sharing an experience with others in an activity or enterprise; therefore suggesting participation requires “both action and connection” (p. 55). Reification is a process that Wenger claimed is central to every CoP. He defined reifying as taking something (e.g., an experience) that is abstract and making it into something (e.g., a meaning) that is concrete. Using a wide range of reification processes (e.g., making, designing, representing, describing, perceiving, and interpreting) “human experience and practice are congealed into fixed forms and given the status of object” (p. 59).

Wenger described the participation and reification as a duality rather than opposites. To clarify this assertion he explained,

> Participation and reification both require and enable each other. On the one hand, it takes our participation to produce, interpret, and use reification; so there is no reification without participation. On the other hand, our participation requires interaction and thus generates short-cuts to coordinated meanings that reflect our enterprises and our takes on the world; so there is no participation without reification. (p. 66)

With respect to this study, the teachers' participation and processes of reification played an integral part in the negotiation of meaning for their CoP. For example, based on their participation (action and connection with one another) and reification of such abstract concepts as inquiry and curricular connections, they developed a set of practices unique to their community.

Regarding Silva's (2000) findings on team teaching, the duality between participation and reification in the negotiation of meaning for a CoP plays an important role in how a curriculum is implemented. With regards to the team in this study, the characteristics of their CoP (e.g., commitment to professional development and individual expertise) guided their processes of participation and reification. In turn this led to both explicit and tacit negotiation of meaning about designing and implementing a coherent curriculum.

Conclusions

What Can Be Learned From This Case?

The overarching research question for this study asked: How does this team of second grade teachers teach science and how does this influence how they teach other subjects? In response to the first part of this question, I learned that these teachers viewed science as the foundation for their curriculum. They taught science from an inquiry perspective and emphasized the development of students' process skills throughout all investigations.

With regards to the second part of the question, I learned that their inquiry-based approach to teaching science was also the lens they used to guide their teaching of other subjects. This lens included the threading of the process skills of scientific inquiry and a learning cycle instructional strategy throughout all their teaching. This approach led to continuity in teaching among the four teachers and the development of a model of curriculum coherency that was employed across all subjects.

Four key findings address the call for reform in elementary teaching:

- Science has the ability to play a significant role in the design and implementation of a coherent curriculum.
- Inquiry-based instruction is not a teaching approach for science only.
- The process skills of scientific inquiry and the learning cycle instructional approach can be used as tools for developing a coherent curriculum.
- Teachers need opportunities for professional collaboration in order for a coherent curriculum approach to be successful.

What Is The Significance Of This Study In Relation To The Research?

In Chapter Two, I discussed three gaps in the research literature that this study addresses. The first was Crawford's (2000) call for more classroom-based studies of teachers using inquiry approaches to teaching science. Although Crawford's study was focused on the secondary level, my study provides support for the use of inquiry-based teaching in elementary schools. As a result, this study demonstrates how science can play as important a role in elementary classrooms as mathematics and literacy.

Second, researchers in both inquiry-based and integrated instruction discussed a disconnect between teachers' views of how to teach an inquiry-based or connected curriculum and their practice of both. This case study offers a model of how to transform views of both topics into the practice of designing and implementing an inquiry-based coherent curriculum.

The third gap in the research was the concept of professional collaboration. From this case study I learned about the role this team's CoP had on their overall teaching. Unlike most of the literature on communities of practice in educational settings, these teachers formed their community and the characteristics of practice within this community on their own. As described in the model of curriculum coherency, their team meetings, where they reinforced their CoP, played a critical role in the overall function of their coherent curriculum model.

Implications

The need for a strong science presence in elementary schools is a current theme among researchers and policy makers. To achieve this presence, teachers need to be aware of the connections between science and other subjects. Encouraging teachers to think of curriculum design from a coherent perspective rather than as individual disciplines may help to bring a more balanced curriculum to elementary classrooms. Thus, this study provides implications for elementary teaching, teacher education, and professional development.

Implications for Elementary Teaching

While this study focused on a unique case of four teachers, a few key aspects can be extracted and used to guide teachers who want to develop a similar model of teaching. This team's model requires teachers to adopt an inquiry-based approach to teaching across their curriculum. The team's beliefs about inquiry-based teaching mirrors the essential features of classroom inquiry discussed in the science inquiry standards (NRC, 2000) (see Appendix I). Therefore, this table is a valuable resource for teachers to refer to with regards to what their role and their students' role should be in an inquiry-based classroom (NRC, 2000). The table in Appendix I describes variations of inquiry to use in science classrooms, but the general premise of each essential feature and the amount of learner self-direction discussed in the variations are strategies that are applicable to all subject areas. Teachers need sustained support from colleagues and administrators as they modify their teaching practice.

A significant component of success for the team in this study was their professional collaboration with one another. Teachers with similar teaching beliefs should band together and support one another as they translate their beliefs into practice. As a group they need to approach administration for support, such as scheduling shared weekly planning time. During these shared planning sessions the team needs to work on developing characteristic unique to their community of practice (Wenger, 1998). This means they need to a) define how each member will contribute to the growth of the group, b) together establish learning goals that will guide instruction across all team members' classrooms, and c) devise a common teaching strategy that will lead them to their own model of curriculum coherency. Therefore, one could suggest that the first step to implementing a coherent curriculum model, similar to the one this team used, is the support of school administration and the scheduling of common planning time for teaching teams.

Implications for Elementary Teacher Education

While classroom management issues are a concern for most teachers, it is especially a worry for new teachers (Beck et al, 2000). Because new teachers lack the teaching experience Brenda, Tracy, Heather, and Nancy had with establishing classrooms norms, it is something teacher preparation programs need to give preservice teachers more experience with. To do this teacher education programs need to provide students with a better foundation of what classroom norms are, how to negotiate classroom norms with students, and have them observe multiple teachers negotiate and implement classroom norms with their own students.

In many cases content methods courses are offered in a block, providing an ideal opportunity for teacher educators to model the type of professional collaboration and curricular connections of a coherent curriculum. Akerson and Flanigan (2000) noted that perhaps the learning outcomes described in their study would have been even stronger had the science methods instructor been willing to collaborate with Akerson in designing a coherent approach. However, Kirst et al. (1997) explained that this type of collaboration is sometimes difficult because not all members of a teaching team will necessarily agree with the process. Therefore, explicit negotiation around meaning of curriculum coherency would need to take place among all community members of the collaborating team to ensure a common view is conveyed to the students.

Teacher preparation programs also provide the ideal location for introducing the principles of designing a coherent curriculum. Offering a methods course towards the end of a preservice program that focuses specifically on interdisciplinary or integrated instruction could provide students with a culminating experience of how to develop a coherent curriculum for their own teaching practice. Having the content courses first gives students the opportunity to develop their pedagogical content knowledge (PCK) (Shulman, 1986) for each discipline. With a solid PCK foundation common instructional approaches (e.g., process skills or learning cycle) can be highlighted in a curriculum design course. Such a course needs to focus on helping students to develop their own model of curriculum coherency while maintaining the integrity of each discipline (Lederman & Neiss, 1998).

The inquiry-based model of curriculum coherency derived from this study could be used as a blueprint for teacher educators to consider as they make changes to their teacher education programs. Such a model provides students with first-hand experience of how a coherent curriculum is designed and implemented into practice. This kind of experience provides a personal connection (Baker & Saul, 1994) and is essential for students to develop their own understanding of how to transfer constructivist views into practice (Beck et al., 2000; Frykolm & Glasson, 2005; Lehman, 1994; Levitt, 2001).

Implications for Professional Development

Similar to preservice teachers, inservice teachers need first-hand experience in designing and implementing curriculum coherency. The experience begins with professional developers designing programs that model an inquiry-based coherent curriculum. During the core of the program, an emphasis needs to be placed on developing communities of practice. It is in these small learning communities where the reform movement state necessary for change will occur (Silva, 2000; Supovitz, 2002).

Loucks-Horsley, Love, Stiles, Mundry, and Hewson (2003) explained that an effective professional development design takes into account the need for sustainability. Communities of practice developed within the context of a professional development, if encouraged to carry on beyond the core professional development program, have the potential to provide the necessary support for sustainability. Much like the teachers in this study, having a community of practice to lean on can provide teachers with the support they need to implement strategies learned in professional development into their own teaching. Communities of practice not only provide teachers with an opportunity for professional collaboration, but also an outlet to discuss problems, share resources, and celebrate when things go as planned.

Directions for Future Research

The goal of this study was to understand how this team of teachers used science to design and implement a coherent curriculum. This goal has been achieved, but in the era of accountability the question policy makers want to know is: How effective is this approach with regards to student learning?

As an elementary teacher educator, and more specifically an elementary science teacher educator, I believe we need to first gain more information about elementary teachers' beliefs and practices of science and curriculum integration before we can begin to address the question of the affect on student learning. While my study is a start, it examines only one case of teachers. Additional studies need to examine other models of curriculum coherency; researchers need to compare these models to determine their affect on student learning.

In order for this to occur, teacher educators must first collaborate to design and implement teacher preparation and professional development programs. Within these collaborative experiences, they should examine curriculum materials claiming to be coherent in nature. Teachers need to have the confidence and willingness to ask if these curricula are encouraging reform-based practice of making curricular connections. Are the connections *visible and explicit* (Beane, 1995)? Are the connections threaded throughout the curriculum in such a way that the integrity of each discipline is still maintained but the process for learning is fluid?

Beyond the examination of curriculum materials, this study indicates the need for further research on teacher developed collaborations; the characteristics of these collaborations and their impact on teaching. Also, there needs to be examination of other CoPs who design and implement a coherent curriculum practice. A limitation to this study is that it examines the practice of only a single case of teachers. Before we can fully understand the advantages or disadvantages of a coherent approach, additional cases are needed. Not only will this support Crawford's (2000) call for more classroom-based research, but it will also provide an opportunity for further study into the role of professional collaboration within each case and across the cases.

The model of curriculum coherency in this study was structured around the use of a learning cycle approach and the development of students' process skills for scientific inquiry. At the time of this study, most of the research on the use of the learning cycle approach focused on high school science teaching (Abraham & Renner, 1986; Renner et al., 1988) and texts (Musheno & Lawson, 1999). However, the teachers of this study show that a learning cycle approach also fits with elementary teaching and learning. The goal of a learning cycle approach is to provide students with an opportunity to explore before explain, and according to the high school studies this has a positive effect on student learning. Future research needs to ask: Does this approach of explore before explain have a positive outcome on elementary students' understanding of science and their abilities to do science? How does this kind of approach impact their motivation to learn science?

The second aspect of curriculum coherency found in this study was the teachers' threading of process skills throughout the curriculum. While there is a significant amount of research in both science and literacy on the synergistic relationship of the process skills between the two disciplines, there is little evidence of this relationship with other disciplines. Are the process skills between science and mathematics, or science and social studies also similar? This study reported some preliminary findings to indicate that this kind of relationship does occur between science and mathematics, but further research needs to be done to support or refute these findings, as well as look at the relationship of process skills between science and other subjects.

Finally, as a science teacher educator, my greatest responsibility will be working with preservice teachers. Therefore, the next phase of my research on this topic includes working with colleagues to provide preservice teachers with first-hand experiences of an inquiry-based coherent curriculum and assess how this approach impacts their views of teaching science. The *National Science Education Standards* (NRC, 1996) and the *Benchmarks for Science Literacy* (AAAS, 1993) both call for a stronger emphasis in teaching the connections between science and other disciplines. Providing preservice teachers the foundation in their teacher education programs is an important step towards answering this call.

REFERENCES

Abell, S. K. (1990). A case for the elementary science specialist. *School Science and Mathematics, 90*, 291-301.

Abell, S. K., & Roth, M. (1992). Constraints to teaching elementary science: A case study of a science enthusiast student teacher. *Science Education, 76*, 581-595.

Abraham, M. R. (2003). The learning cycle approach as a strategy for instruction in science. In B. Fraser & K. G. Tobin (Eds.) *International Handbook of Science Education* (pp. 513-524). Dordrecht, the Netherlands: Kluwer Academic Publishers.

Abraham, M. R., & Renner, J. W. (1986). The sequence of learning cycle activities in high school chemistry. *Journal of Research in Science Teaching, 23*, 21-43.

Akerson, V. L., & Flanigan, J. (2000). Preparing preservice teachers to use an interdisciplinary approach to science and language arts instruction. *Journal of Science Teacher Education, 11*, 345-362.

American Association for the Advancement of Science. (1993). *Benchmarks for science literacy*. New York: Oxford University Press, Inc.

American Association for the Advancement of Science. (1998). *Blueprints for reform: Project 2061.* New York: Oxford University Press, Inc.

Atkin, J. M., & Black, P. (2003). Inside science education reform: A history of curricular and policy change. New York: Teachers' College Press.

Baker, L. (1991). Metacognition, reading, and science education. In C. M. Santa & D. E. Alvermann (Eds.), *Science learning: Processes and applications* (pp. 2-13). Newark, DE: International Reading Association.

Baker, L., & Saul, W. (1994). Considering science and language arts connections: A study of teacher cognition. *Journal of Research in Science Teaching, 31*, 1023-1037.

Beane, J. A. (1995). Introduction: What is a coherent curriculum. In J. A. Beane (Ed.) *Toward a coherent curriculum* (pp. 1-14). Alexandria, VA: Association for Supervision and Curriculum Development.

Beck, J., Czerniak, C. M., & Lumpe, A. T. (2000). An exploratory study of teachers' beliefs regarding the implementation of constructivism in their classrooms. *Journal of Science Teacher Education, 11*, 323-343.

Boyer, E. L. (1995a). *The basic school: A community for learning.* Princeton, NJ: The Carnegie Foundation for the Advancement of Teaching.

Boyer, E. L. (1995b). The educated person. In J. A. Beane (Ed.) *Toward a coherent curriculum* (pp. 16-25). Alexandria, VA: Association for Supervision and Curriculum Development.

Bryan, L. A. (2003). Nestedness of beliefs: Examining a prospective elementary teacher's belief system about science teaching and learning. *Journal of Research in Science Teaching, 40*, 835-868.

Bybee, R. W. (2000). Teaching science as inquiry. In J. Minstrell & E. H. van Zee (Eds.) *Inquiring into inquiry learning and teaching in science* (pp. 14-19). Washington, D.C.: American Association for the Advancement of Science.

Caine, R. N., & Caine, G. (1993). Understanding a brain-based approach to learning and teaching, In R. Fogarty (Ed.), *Integrating the curricula: A collection* (pp. 9-20). Arlington Heights, IL: IRI/Skylight Training and Publishing, Inc.

Calkins, L. M., & Oxenhorn, A. (2003). *Small moments: Personal narrative writing.* Portsmouth, NH: Heinemann.

Casteel, C. P., & Isom, B. A. (1994). Reciprocal processes in science and literacy learning. *The Reading Teacher, 47,* 538-545.

Century, J. R., Flynn, J., Makang, D. S., Pasquale, M., Robblee, K. M., Winokur, J., & Worth, K. (2002). Supporting the science-literacy connection. In R. W. Bybee (Ed.), *Learning science and the science of learning* (pp. 37-49). Arlington, VA: NSTA Press.

Collins, A. (1997). National science education standards: Looking backward and forward. *The Elementary School Journal, 97*, 299-313.

Confer, C. (1994). *Math by all means: Geometry, grades 1-2*. Sausalito, CA: Math Solutions Publications.

Crawford, B. A. (2000). Embracing the essence of inquiry: New roles for science teachers. *Journal of Research in Science Teaching, 37*, 916-937.

Czerniak, C. M., & Lumpe, A. T. (1996). Relationship between teachers beliefs and science education reform. *Journal of Science Teacher Education, 7,* 247-266.

DeBoer, G. (1991). *A history of ideas in science education: Implications for practice.* New York: Teachers College Press.

Denzin, N. K., & Lincoln, Y. S. (Eds.). (2000). *Handbook of qualitative research* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Dickinson, V. L., & Young, T. A. (1998). Elementary science and language arts: Should we blur the boundaries? *School Science and Mathematics, 98*, 334-339.

Drake, S. (1993). *Planning integrated curriculum: The call to adventure.* Alexandria, VA: Association for Supervision and Curriculum Development.

Drake, S. M., & Burns, R. C. (2004). *Meeting standards through integrated curriculum.* Alexandria, VA: Association for Supervision and Curriculum Development.

Earl, R. D., & Winkeljohn, D. R. (1977). Attitudes of elementary teachers toward science and science teaching. *Science Education, 61*, 41-45.

Fetters, M. K., Czerniak, C. M., Fish, L., & Shawberry, J. (2002). Confronting, challenging, and changing teachers' beliefs: Implications from a local systemic change professional development program. *Journal of Science Teacher Education, 13*, 101-130.

Fogarty, R. (1993). Ten ways to integrate curriculum. In R. Fogarty (Ed.), *Integrating the curricula: A collection* (pp. 101-110). Arlington Heights, IL: IRI/Skylight Training and Publishing, Inc.

Ford, C., Yore, L., D., & Anthony, R. J. (1997). *Reforms, visions , and standards: A cross-cultural curricular view from an elementary school perspective.* Paper presented at the annual meeting of the National Association of Research in Science Teaching, Oak Brook, IL (ERIC Document Reproduction Service No. ED406168).

Foulger, T. (2005). Innovating professional development standards: A shift to utilize communities of practice. *Essays in Education, 14*, 1-14.

Friedman, A. (1995). *A cloak for the dreamer*. New York: Scholastic, Inc.

Frykholm, J., & Glasson, G. (2005). Connecting science and mathematics instruction: Pedagogical context knowledge for teachers. *School Science and Mathematics, 105*, 127-141.

Gaff, J. G. (1993). The resurgence of interdisciplinary studies. In R. Fogarty (Ed.), *Integrating the curricula: A collection* (pp. 61-67). Arlington Heights, IL: IRI/Skylight Training and Publishing, Inc.

Gaskins, I. W., & Guthrie, J. T. (1994). Integrating instruction of science, reading, and writing: Goals, teacher development, and assessment. *Journal of Research in Science Teaching, 31*, 1039-1056.

Glynn, S. M., & Muth, D. (1994). Reading and writing to learn science: Achieving scientific literacy. *Journal of Research in Science Teaching, 31*, 1057-1073.

Gonzales, P., Guzmán, J. C., Partelow, P., Pahlke, E., Jocelyn, L., Kastberg, D., et al. (2004). *Highlights From the Trends in International Mathematics and Science Study (TIMSS) 2003* (NCES 2005–005). U.S. Department of Education, National Center for Education Statistics. Washington, DC: U.S. Government Printing Office.

Grady, J. B. (1994, March). *Interdisciplinary curriculum development*. (Clearinghouse No. PS022647). Paper presented at the meeting of the Association for Supervision and Curriculum Development , Chicago. (ERIC Document Reproduction Service No. ED373903)

Harlen, W. (Ed.). (2001). *Primary science…taking the plunge: How to teach primary science more effectively for ages 5 to 12 (2nd Ed.)*. Portsmouth, NH: Heinemann.

Hung, D., Chee, T. S., Hedberg, J. G., & Seng, K. T. (2005). A framework for fostering a community of practice: Scaffolding learners through an evolving continuum. *British Journal of Educational Technology, 36*, 159-176.

Huntley, M. (1998). Design and implementation of a framework for defining integrated mathematics and science education. *School Science and Mathematics, 98*, 320-327.

International Reading Association & National Council of Teachers of English. (1996). *Standards for the English language arts.* Newark, DE: Author.

Jacobs, H. (Ed.). (1989). *Interdisciplinary curriculum: Design and implementation.* Alexandria, VA: Association for Supervision and Curriculum Development.

Janesick, V. J. (2000). The choreography of qualitative research design: Minuets, improvisations, and crystallization. In N. K. Denzin & Y.S. Lincoln (Eds.), *Handbook of qualitative research* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Jones, M. G., Carter, G., & Rua, M. J. (1999). Children's concepts: Tools for transforming science teachers' knowledge. *Science Education, 83*, 545-557.

Kagan, D. M. (1992). Implications of research on teacher belief. *Educational Psychologist, 27*, 65-90.

Karplus, R. (1977). Science teaching and the development of reasoning. *Journal of Research in Science Teaching, 14*, 169-175.

King, K., Shumow, L., & Lietz, S. (2001). Science education in and urban elementary school: Case studies of teacher beliefs and classroom practices. *Science Education, 85*, 89-110.

Kirst, M. W., Anhalt, B., & Marine, R. (1997). Politics of science education standards. *The Elementary School Journal, 97*, 315-328.

Laplante, B. (1997). Teachers' beliefs and instructional strategies in science: Pushing analysis further. *Science Education, 81*, 277-294.

Lederman, N. G. & Niess, M. L. (1998). 5 Apples + 4 Oranges = ? [Editorial]. *School Science and Mathematics, 98*, 281-284.

Lehman, J. R. (1994). Integrating science and mathematics: Perceptions of preservice and practicing elementary teachers. *School Science and Mathematics, 94*, 58-64.

Levitt, K. E. (2001). An analysis of elementary teachers' beliefs regarding the teaching and learning of science. *Science Education, 86*, 1-22.

Lincoln, Y.S. & Guba, E. G. (2000) Paradigmatic controversies, contradictions, and emerging confluences. In N. K. Denzin & Y.S. Lincoln (Eds.), *Handbook of qualitative research* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Loucks-Horsley, S., Love, N., Stiles, K. E., Mundry, S., & Hewson, P. W. (2003). *Designing professional development for teachers of science and mathematics* (2nd ed.*)*. Thousand Oaks, CA: Corwin Press, Inc.

Luera, G. R., & Otto, C. A. (2005). Development and evaluation of an inquiry-based elementary science teacher education program reflecting current reform movements. *Journal of Science Teacher Education, 16*, 241-258.

Manouchehri, A. (2001). Collegial interaction and reflective practice. *Action in Teacher Education, 22*(4), 86-97.

Mitchell, J. C. (1984). Producing data: Case studies. In R. F. Ellen (Ed.), *Ethnographic research: A guide to general conduct*. London: Academic Press.

Moore, K. D., & Blankenship, J. W. (1977). Teaching basic science skills through realistic science experiences in the elementary school. *Science Education, 61*, 337-345.

Morse, J. M., & Richards, L. (2002). *Readme first for a user's guide to qualitative* *methods.* Thousand Oaks, CA: Sage Publication.

Moustakas, C. E. (1994). *Phenomenological research studies*. Thousand Oaks, CA: Sage Publications.

Musheno, B. V., & Lawson, A. E. (1999). Effects of learning cycle and traditional text on comprehension of science concepts by students at differing reasoning levels. *Journal of Research in Science Teaching, 36*, 23-37.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics.* Reston, VA: Author.

National Council for the Social Studies. (1994). *Expectations for excellence: Curriculum standards for social studies.* Washington, D.C.: Author.

National Research Council. (1996). *National science education standards.* Washington, D.C.: National Academy Press.

National Research Council. (2000). Inquiry and the national science education standards: A guide for teaching and learning. Washington, D.C.: National Academy Press.

National Science Resources Center. (1998a). *Science and technology for children™ (STC)*. Burlington, NC: Carolina Biological Supply Company.

National Science Resources Center. (1998b). *STC™ meets the standards: An analysis of the alignment between the Science and Technology for Children™ curriculum and the National Science Education Standards.* Burlington, NC: Carolina Biological Supply Company.

Nespor, J. (1987). The role of beliefs in the practice of teaching. *Journal of Curriculum Studies, 19*, 317-328.

Padilla, M. J., Muth, K. D., & Padilla, R. K. L. (1991). Science and reading: Many process skills in common? In C. M. Santa & D. E. Alvermann (Eds.), *Science learning: Processes and applications* (pp. 14-21). Newark, DE: International Reading Association.

Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research, 62*, 307-332.

Pang, J., & Good, R. (2000). A review of the integration of science and mathematics: Implications for further research. *School Science and Mathematics, 100*, 73-82.

Patton, M. Q. (1990). *Qualitative research and evaluation methods* (2nd ed.). Newbury Park, CA: Sage Publications.

Patton, M. Q. (2002). *Qualitative research and evaluation methods* (3rd ed.). Thousand Oaks, CA: Sage Publications.

Pringle, R. M., & Carrier Martin, S. (2005). The potential impacts of upcoming high-stakes testing on the teaching of science in elementary classrooms. *Research in Science Education, 35*, 347-361.

Raizen, S. A., & Michelsohn, A. M. (Eds.) (1994). *The future of science in elementary schools: Educating prospective teachers*. San Francisco, CA: Jossey-Bass.

Renner, J. W., Abraham, M. R., & Birnie, H. H. (1988). The necessity of each phase of the learning cycle in teaching high school physics. *Journal of Research in Science Teaching, 25*, 39-58.

Roden, J. (2000). Primary science: A second-class core subject? In J. Sears and P. Sorensen (Eds.), *Issues in Science Teaching* (pp. 31-40). London: RoutledgeFalmer.

Rodriguez, I. & Bethel, L. J. (1983). An inquiry approach to science and language teaching. *Journal of Research in Science Teaching, 20*, 291-296.

Rutherford, F. J., & Ahlgren, A. (1989). *Science for all Americans*. New York: Oxford University Press.

Schwab, J. (1960). What do scientists do? *Behavioral Science, 5*, 1-27.

Schwab, J. (1962). The teaching of science as enquiry. In *The teaching of science* (pp. 1-103). Cambridge, MA: Harvard University Press.

Science Curriculum Improvement Study (SCIS). (1970). Chicago: Rand McNally.

Sears, J. (2000). Balanced science: A battle still to be won? In J. Sears and P. Sorensen (Eds.), *Issues in Science Teaching* (pp. 41-49). London: RoutledgeFalmer.

Settlage, J. (2000). Understanding the learning cycle: Influences on abilities to embrace the approach by preservice elementary school teachers. *Science Education, 84*, 43-50.

Shulman, L.S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*, 4-14.

Silva, D. Y. (2000). Collaborative curriculum encounters. *Journal of Curriculum and Supervision, 15*, 279-299.

Stake, R. E. (2000). Case studies. In N. K. Denzin & Y.S. Lincoln (Eds.), *Handbook of qualitative research* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Stoddart, T., Pinal, A., Latzke, M., & Canaday, D. (2002). Integrating inquiry science and language development for English language learners. *Journal of Research in Science Teaching, 39*, 664-687.

Supovitz, J. A. (2002). Developing communities of instructional practice. *Teachers College Record, 104*, 1591-1626.

TERC. (2004). *Investigations in number data and space*. Lebanon, IN: Pearson Scott Foresman.

Tilgner, P. J. (1990). Avoiding science in the elementary school. *Science Education, 74*, 421-431.

Tobin, K., Briscoe, C., & Holman, J. R. (1990). Overcoming constraints to effective elementary science teaching. *Science Education, 74*, 409-420.

Trowbridge, L. W., Bybee, R. W., & Carlson-Powell, J. (2004). *Teaching secondary school science: Strategies for developing scientific literacy* (8th ed.). upper Saddle River, NJ: Prentice Hall

Van Manen, M. (1990). *Researching lived experience: Human science for an action sensitive pedagogy*. New York: State University of New York Press, SUNY.

Vars, G. F. (1993). Integrated curriculum in historical perspective. In R. Fogarty (Ed.), *Integrating the curricula: A collection* (pp. 91-94). Arlington Heights, IL: IRI/Skylight Training and Publishing, Inc.

Vars, G. F., & Beane, J. A. (2000). *Integrative curriculum in a standards-based world* (ERIC Digest). Champaign, IL: ERIC Clearinghouse on Elementary and Early Childhood Education. (ERIC Document Reproduction Service NO. ED441618).

Wenger, E. (1998). *Communities of practice*. New York: Cambridge University Press.

Wesley, P. W., & Buysse, V. (2001). Communities of practice: Expanding professional roles to promote reflection and shared inquiry. *Topics in Early Childhood Special Education, 21*, 114-123.

Wolcott, H. F. (1995). *The art of fieldwork.* Walnut Creek, CA: AltaMira Press.

Yore, L. D., Shymansky, J. A., & Anderson, J. O. (2005). Sensing the impact of elementary school science reform: A study of stakeholder perceptions of implementation, constructivist strategies, and school-home collaboration. *Journal of Science Teacher Education, 16*, 65-88.

Young, B. J., & Kellogg, T. (1993). Science attitudes and preparation of preservice elementary teachers. *Science Education, 77*, 279-291.

Appendix A

Ten Views for Integrating Curriculum

View	Lens	Description	Example
Fragmented	Periscope – one direction; one sighting; narrow focus on single discipline.	The traditional model of separate and distinct discipline, which fragments the subject area.	Teacher does not make any connections within a discipline or between other disciplines.
Connected	Opera glass – details of one discipline; focus on subtleties.	Within each subject area, course content is connected topic to topic, concept to concept, one year's work to the next, and relates ideas explicitly.	Teacher relates the concept of fractions to decimals, which in turn relates to money, grades, etc.
Nested	3-D glasses – multiple dimensions to one science, topic, or unit.	Within each subject, the teacher targets multiple skills: a social skill, a thinking skill, and a content-specific skill.	Teacher designs the unit on photosynthesis to target consensus seeking, sequencing, and plant life cycle.
Sequenced	Eyeglasses – varied internal content framed by broad, related concepts.	Topics or units of study are rearranged and sequenced to coincide with one another. Similar ideas are taught in concert while remaining separate subjects.	English teacher presents a historical novel depicting a particular period while the History teacher teaches that same period.
Shared	Binoculars – two disciplines that share overlapping concepts and skills.	Shared planning and teaching take place in two disciplines in which overlapping concepts or ideas emerge as organizing elements.	Science and Math teachers use data collection, charting, and graphing as shared concepts that can be team-taught.

View	Lens	Description	Example
Webbed	Telescope – broad view of an entire constellation as one theme, webbed to the various elements.	A fertile theme is webbed to curriculum contents and disciplines; subjects use the theme to sift out appropriate concepts, topics, and ideas.	Teacher presents a simple topical theme, such as the circus, and webs it to other subject areas.
Threaded	Magnifying glass – big ideas that magnify all content through a metacurricular approach.	The metacurricular approach threads thinking skills, social skills, multiple intelligences, technology, and study skills through the various disciplines.	Teaching staff targets prediction in Reading, Math, and Science while Social Studies teacher targets forecasting current events.
Integrated	Kaleidoscope – new patterns and designs that use the basic elements of each discipline.	This interdisciplinary approach matches subjects for overlaps in topics and concepts with some team teaching in an authentic integrated model.	In Math, Science, Social Studies, Fine Arts, etc. teachers look for patterning models and approach content through these patterns.
Immersed	Microscope – personal view allowing for detailed explanation as all content is filtered through interest and expertise.	The disciplines become part of the learner's lens of expertise: the learner filters all content through this lens and becomes immersed in his or her own experience.	Student or doctoral candidate has an area of expert interest and sees all learning through that lens.
Networked	Prism – a view that creates multiple dimensions and directions of focus.	Learner filters all learning through the expert's eye and makes internal connections that lead to external networks of experts in related fields.	Architect, while adapting the CAD/CAM technology for design, networks with programmers and expands her knowledge base.

Note: Adapted from *Integrating the curricula: A collection* (p. 103), by Robin Fogarty (Ed.), 1993, Arlington Heights, IL: IRI/Skylight Training and Publishing.

Appendix B

Initial Email from Tracy Stating the Team Agrees to Participate

From: Tracy Sent: Mon. 9/13/2004 4:16 PM
To: Rogers, Meredith Anne Park(UMC-Student)
Cc:
Subject: RE: Meredith's dissertation-touching base

Meredith,

All 2nd-grade teachers are fine working with you on your dissertation.

Just let us know when things are ready to go and we'll schedule from there. We are very flexible and know this whole process takes time and is not really in your control. Just keep us posted. Good luck! Oh, and I guess I'll see you soon.

Tracy

[redacted]
Clinical Associate
[redacted]
2616 [redacted]
[redacted]

Appendix C

The School District's Request for Research

[redacted] PUBLIC SCHOOLS
Administration Building
1818 West Worley Street
[redacted]
[redacted] Fax: [redacted]

Request for Research

Request made by: Meredith Park Rogers **Date:** November 2, 2004
Address: 4010 West Broadway, Apt. G
City/Zip: Columbia, Missouri 65203 **Phone:** [redacted]
Advisor: Dr. Sandra K. Abell - Professor of Science Education,
University of Missouri - Columbia
Department: Learning Teaching and Curriculum – Science Education
Title of Research: Collaboration in planning and implementing science instruction using an Interdisciplinary approach: The lived experience of second grade teachers

Briefly state the purpose of the research:

The purpose of this study is to follow up the suggestion, as discussed within science education literature, for need to gather classroom-based research by observing and interviewing teachers who practice this instructional method regularly to teach science. In particular, I will observe how a team of second grade teachers work collaboratively to design and implement an interdisciplinary curriculum. Therefore, the purpose of my study is to develop an understanding of this teaching team's lived experience of using an interdisciplinary method of instruction. With this understanding, a potential implication of my study may include using what I have learned from this single case study to help others to design and implement interdisciplinary curricula incorporating science.
My main research question is: How does a team of teachers collaborate to plan and implement science instruction using an interdisciplinary approach?

Briefly describe the research and how and to what extent the [redacted] Public Schools would be involved if the request is granted:

The two main data sources for this study are interviews and observations. Artifacts such as curriculum planning schedules, scoring rubrics, lesson plans and class handouts developed by the team for instructional purposes will also be collected, copied and examined for the purpose of supporting themes that develop from the interview and observation data. There are three semi-structured interviews to be conducted with the purposively selected teaching team from [redacted] Elementary. Two are with each of the four second grade teachers (pre and post observational data period). The third is to be conducted with the school principal at the beginning of the data collection period. I have designed an open-ended, conversational interview protocol that I can adapt as necessary for each teacher or situation that I am asking for more information about. For example, I may interject conversational questions during the teachers' planning meetings if I want them to provide a more detailed explanation of a particular instructional method they are discussing to use with a portion of their interdisciplinary unit. Also, if I observe the teachers implementing the lessons very differently from one another, or from how they described implementing it during their previous team planning meeting, I will then ask them to explain why they chose to make these changes.

I will collect field notes in two different forums: 1) during team planning sessions, and 2) while observing the team of second grade teachers at [redacted] Elementary individually teach. The purpose of collecting field notes of their curriculum planning is to focus on the team's process for designing an interdisciplinary unit of instruction, as well as their interactions during these discussions. My intention with collecting classroom observations is to make comparisons in teaching strategies used to implement an interdisciplinary unit. I will note strategies that are similar and different between the teachers. Taking field notes during both of these situations will also provide me with the opportunity to see what sort of obstacles they encounter during implementation and learn how their team, as well as each teacher, overcomes them.

Description of school population needed:

The team of four second grade teachers and the principal of [redacted] Elementary school are the only participants of this study. There will be on student involvement in the data collection procedures of this study.

Number of Students:

Number 0	Grade Level 0	Number of Sessions 0
Number	Grade Level	Number of Sessions
Number	Grade Level	Number of Sessions
Number	Grade Level	Number of Sessions
Number	Grade Level	Number of Sessions
Number	Grade Level	Number of Sessions

Amount of time per session:

- 1 hour/day of classroom observation (M, T, TH, F) beginning January 3, 2005 to March 18, 2005 (excluding the week of January 17-21 because I will be out of town).
- 1-1.5 hours per week of observing and possibly informally interviewing the teaching team during their planning sessions.
- 45 mins. for individual teacher semi-structured pre and post interviews
- 45 mins. for the principal's one interview

Length of time between sessions:

- There will be one day in between observations sessions, except between Tuesday and Thursday. I will not be observing on Wednesday's because the team does not teach their interdisciplinary thematic unit that day.

Will the researcher and/or his/her assistant(s) be conducting the sessions with students?
Yes No

Are any Columbia Public School staff members to be involved?
Yes X No

If *"YES,"* in what way?

As described in other sections of this request form I will be observing and talking with the second grade team at [redacted] elementary. It is their collaborative approach in designing and implementing an interdisciplinary curriculum that I am interested in understanding and sharing with others. The school principal will be involved in my study for the purpose of providing background information on the curricular vision of the school, to describe any support structures provided to these teachers, and comparing this teams instructional methods in comparison to the other teaching teams in her school.

When will each student be involved?

Not required for this study.

How will each student be involved?

Not applicable

Approved by:

______________________________	______________________________
Principal/Coordinator Signature Date	Assistant Superintendent Signature Date

Appendix D

Written Consent Form

December ___, 2004

Dear Participant,

This letter seeks permission for your participation in a non-funded dissertation project entitled, “Collaboration in planning and implementing science instruction using an interdisciplinary approach: The lived experience of second grade teachers”. This letter outlines the purpose, procedures, duration, the participant’s role, benefits to the participant, and any potential risks as a result of your participation in the project. Issues of confidentiality, voluntary participation and the approval for studying human subjects are outlined as well.

Purpose of Research

For my study I am observing and speaking with a team of second grade teachers about their experience of designing and implementing an interdisciplinary curriculum. The purpose of my study is to develop an understanding of how a team of four grade two teachers collaborate to design and implement an interdisciplinary curriculum that incorporates science.

Specific Procedures to be used for the Entire Study

I will collect the following data: 1) two individual teacher interviews – one at the beginning of the data collection period and the second at the end; 2) individual or whole group interviews with the teachers periodically throughout the data collection period for the purpose of clarifying observations in the classroom and/or during team planning sessions; 3) observational field notes of the classroom teaching for each teacher during the interdisciplinary units called: Changes and Geology/Soils; 4) a single interview with the school principal; 5) review of instructional artifacts (i.e., Ernest Boyer’s “Basic School” book, classroom handouts, long term and short term planning goals for the team and individually, etc.)

Duration of Participation

December 2004 to April 2005 for data collection

Teacher Participant’s Role in the Project

Each teacher will participate in two individual semi-structured interviews. The first interview will focus on the teacher's previous teaching experiences and their efforts in the collaboration of designing an interdisciplinary curriculum that incorporates science. The second individual interview will occur after a 10 week period of classroom observation and will focus on reflecting about the implementation process of the curriculum. In addition to these interviews there is the potential for open-ended and unstructured mini-interviews with a teacher or the team as a whole during the 10 weeks of classroom observation. The purpose of these discussions is to clarify any questions I may have regarding their implementation strategies.

Principal's Role in the Project

To participate in one interview in order to provide background information on the curricular vision of the school and the dynamics of the second grade teaching team on their own, as well as in comparison to the other grade level teams in the school.

Benefits to the Participant

Using the various interviewing techniques will require the teachers to reflect individually as well as a team about their planning and implementation of the curriculum. This type of reflective practice is often encouraged, but rarely allowed time for in schools, so a benefit of this study for the teachers is that it will provide the time to be reflective about their teaching.

A benefit of this study for the principal is also to provide an opportunity to reflect on the curricular practices of her school. In particular, she will be asked to consider how the *Basic School* program is continuing to influence the school's curriculum and if they, as whole staff, are accomplishing the priorities outlined in the *Basic School* philosophy.

Risks to the Individual

For all teacher participants, I perceive no risks to you, and no judgments or evaluation will be made on your classroom instruction for the purpose of review by the institution of the University of Missouri – Columbia or the Columbia Public School District. For the principal, I perceive no risks to you, with regards to your administrative responsibilities.

Confidentiality

Regarding the collection of observational data, a pseudonym will be assigned to any data originating from you; thus your personal identity will be held confidential. You will not be included by name in any future report resulting from this study, unless you wish otherwise.

Voluntary Nature of Participation

You do not have to participate in this research project. If you do agree to participate you can withdraw your participation at any time without penalty.

Human Subject Statement
This project has been reviewed and approved by the University of Missouri-Columbia Institutional Review Board. The Board believes the research procedures adequately safeguard your privacy, welfare, civil liberties, and rights. If you have any questions, you may reach me at (573) 234-2810. For additional information regarding human subjects participation in research, please contact the University of Missouri-Columbia IRB office at (573) 882-9585.

If you are willing to participate in this project, please complete the consent form below.

Sincerely,

Meredith A. Park Rogers
Doctoral Candidate
Principal Investigator

Contact Information:
303 Townsend Hall
Columbia, MO 65211-9033
VOICE (573) 234-2810
FAX (573) 446-0061
Email: map6cb@mizzou.edu

Consent Form

ALL SECOND GRADE TEACHERS AND PRINCIPAL OF
[redacted] ELEMENTARY SCHOOL

I, ________________________________ agree to participate in the research project entitled "Collaboration in planning and implementing science instruction using an interdisciplinary approach: The lived experience of second grade teachers" conducted by Meredith A. Park Rogers, a doctoral candidate in the College of Education, Department of Curriculum and Instruction of the University of Missouri – Columbia.

I understand that:

- My participation is voluntary and that I must be 18 years of age to participate.
- My identity will be kept confidential.

- I will not need to provide personal background information other than past teaching experiences.
- I understand that all interviews will be audio-taped.
- Meredith Park Rogers will be in the teachers classrooms at various times during a 10 week period to observe their instructional approach to teaching an interdisciplinary curriculum.

I have read the 2 page letter above and am aware of my role within the project. I understand that I may contact Meredith Park Rogers with any questions or concerns at any time during the course of her study.

I agree to participate in this project and realize that I may withdraw without penalty at any time.

______________________________ ____________________

Participant's Signature Date

____

Participant's Name

Appendix E

Principal's Interview Protocol

Before turning on the tape to record the interview explain that I will be asking the principal to acknowledge on tape that this interview is being recorded. Explain that I will begin by stating my name, the date and the name of the interviewee.

Share with the principal:
The purpose of this interview is gather some information on the type of curricular methods that are advocated in your school to develop a better understanding of what may be influencing how the second grade teachers are planning their curriculum.
Do you have any questions before we begin?

<Begin recording>

1. Tell me about your teaching and administrative history.
2. What is your current vision for Drake Elementary School?
3. What theories or models of curricular practice currently influence the curriculum design and implementation teachers use at Drake Elementary?
4. Describe what you think are the strengths and weaknesses of using this curricular practice (or approach)?
5. What role do you see the science curriculum having in the design and implementation of the current curricular practice at Drake Elementary?
6. What role does teacher collaboration have in your school's curricular vision?
7. What sorts of supports are offered to teachers in your school to help promote your curricular vision?
8. Tell me about how the second grade teachers approach designing and implementing their curriculum? (Probe: Do you see this as being different from other teachers in other grade levels?)
9. Have you received any comments from parents or school district members with regards to the collaborative and integrated approach that the 2nd grade teachers implement?
10. What is your vision in terms of curriculum development for Drake in the next 5 years? (Probe: What role do you see interdisciplinary playing? What role do you see science playing?)

<u>Conclude the interview:</u>
Ask if there is anything else they would like to add. Thank the interviewee for their participation.

Appendix F

Teachers' First Interview Protocol

Before turning on the recorder to record the interview explain that I will be asking the teacher to acknowledge on tape that this interview is being recorded. Explain that I will begin by stating my name, the date and the name of the interviewee.

<Begin recording>

1. Tell me about your teaching history.
2. Which content areas do you prefer to teach and why?
3. Tell me about a past experience you have had with developing curriculum. (Probe: How did you decide what to teach? Who did you work with to develop the curriculum? How did you find the resources you needed? What problems did you encounter? How did the students respond? What did you learn from that experience that you have used in your subsequent years of teaching?)
4. How have your curriculum design methods changed throughout your teaching career?
5. Describe to me how you go about planning the thematic curriculum you use now.
6. Tell me about the best thematic/interdisciplinary unit you ever taught. (Probe: In what ways to you think this was interdisciplinary?)
7. What role did science serve in designing the unit you just described?
8. How has collaborating with other teachers influenced your current approach to curriculum planning and its implementation?
9. What do you feel you contribute to the collaboration process with the other second grade teachers?
10. What do you rely on the other teachers to contribute during the collaborative process?
11. Tell me about any obstacles your team encountered with trying to plan your "theme" curriculum? How did you overcome the obstacles?
12. If there are any changes you could make to your team's collaborative process, what would they be? (Probe: Would you change anything about the curriculum itself? How would this theme teaching be different if you were not working in a team?)

Conclude the interview: *Ask if there is anything else they would like to add. Thank the interviewee for their time in participating in this first interview and let them know that towards the end my data collection period that I will be conducting a second one-on-one interview.*

Appendix G

Teacher's Second Interview Protocol

Before turning on the tape to record the interview explain that I will be asking the teacher to acknowledge on tape that this interview is being recorded. Explain that I will begin by stating my name, the date and the name of the interviewee.

Share with the teacher participants:
The purpose of this interview is to ask you to reflect on your instructional methods. I would like you to think about the process you take in planning your curriculum, and consider aspects that guide your planning and implementation of your curriculum, strategy (/ies) that you feel works well, and possible changes you are considering for next year. Do you have any questions before we begin?

<Begin recording>

1. How do you think science is connected to other subjects? (Probe: Math, Social Studies, Language Arts, etc.)

2. How do you use these connections in planning and implementing your curriculum? (Probe: Tell me about a time when you used this approach in your teaching.)

3. What role do you believe science has in helping you to plan your second grade curriculum?

4. In what ways do you think your science teaching incorporates inquiry?

5. What do you mean when you say inquiry?

6. How would you say inquiry plays into the "connected" approach that you previously described?

7. How did you employ inquiry throughout your teaching of the 'Changes' unit?

8. What would you say are the process skills associated with inquiry?

9. Before you mentioned that science has the role of ____________ in helping you to plan your second grade curriculum. In what ways do you use the process skills you just described with assisting in the planning of the other various subject areas? (Probe: Why have you decided to teach this way? What are your goals for your students learning?)

10. Characterize your approach to curriculum design before joining this teaching team. How would you characterize your approach to curriculum design now?
11. What advice would you give to others wanting to plan and implement their curriculum similar to how you characterized yours? (Probe: What sort of supports do teachers need to have in place to help them be successful in teaching this way?)

12. What modifications will you make to your curricular design approach for next year? (Probe: How will these modifications affect your approach to teaching science? Other subject areas, such as math, social studies and language arts?

Conclude the interview:
Ask if there is anything else they would like to add. Thank the interviewee for their participation.

Appendix H

Reflective Journal After Observing *Changes* Unit

Dissertation Journal Reflection

February 13, 2005

The teaching team has completed their first theme unit during my observation period called “Changes”. They completed the unit on Friday, Feb. 4th, but had cognitive abilities testing (CAT) all last week so they did not teach science theme. As a result of this testing period I did not collect data as usual. Instead I went to one class in the afternoon on Tuesday (Feb. 8th) and observed a two hour reading and writing session. It was during this time period that I began really began to see the role that the science instruction these teachers are providing for their students supports the rest of their curriculum.

I do not see the interdisciplinary instruction of science with the other disciplines with respect to content; instead the focus is on developing the cognitive abilities associated with scientific inquiry through units of science study and then using these skills throughout the other disciplines. For example, all four teachers often refer to the idea of “predicting” throughout all the subject areas. They have the students predicting in math when problem solving, as well as with predicting or inferring what characters or story lines will do next when reading. They also have students practicing this skill in their own writing so that readers can make predictions about the story lines they are writing. Other skills modeled by the teachers used by the students throughout all content areas are making observations, recording information/data, looking for patterns and relationships, and communicating this information to share with others – sometimes orally and sometimes in written form, such as poster sessions (Brenda) or journals (Brenda, Tracy, & Heather).

Above are the themes I am noticing so far in my preliminary reflections from day to day data collection. However, what I am concerned about is what I am not seeing. My current dissertation question is: *How does a team of teachers collaborate to plan and implement science instruction using an interdisciplinary approach?* My problem is the idea of the teachers "collaborating". Since I one teacher is not even teaching science I am not collecting data on a regular basis from her classroom. Also, the team meetings are not providing me with the details in collaboration as I thought they would. The teachers do collaborate – share ideas, plan out lessons/activities, etc., but for reading, writing and mathematics…not science. The units the other three teachers use for science are purchased (e.g., STC *Changes* kit) or district developed. They have all had so much experience teaching them in the past that they do not need to set aside collaborative planning time. So I do not believe that my original question of research will be answered by the data that I am collecting.

Instead I am seeing another interesting aspect in these three teachers' methods of implementing the pre-designed science curriculum. Although, they all complete the same type of activities sometime throughout the unit, they each have slightly different student initiated inquiries going on throughout the course of study. For example, Heather's class carried an inquiry of study on the effects of heat and airflow on the evaporation rates of water. At the same time, Tracy's class looked at the evaporation rates of different kinds of water (pond, pool, tap, bottled, etc.). Brenda's class continuously referred to a beginning lesson on the evaporation rates of different liquids to help build their conceptual understanding of other investigations they were studying in class.

From my observations so far I see a few interesting ideas in teaching science at the primary grade level:

- The support that science cognitive skills can give to other content areas – it has always be said that language arts (reading and writing) are tools for the core content areas, but these teachers appear to take skills of scientific inquiry and integrated them into the other content areas to help support the students learning of these subjects…sort of a different twist to interdisciplinary instruction.
- The teachers' use of questioning techniques with the students to draw out their ideas for further study's on a topic, which they do in conjunction with the set curriculum.
- Nature of Science - The three teachers of science make a consistent effort to talk about behaviors of scientists, how they design studies, fair tests, communicating results, the social nature of science (working in pairs or teams) and the use of evidence with inferring results.

What I am not seeing is the focus on the teams' collaboration in planning (and therefore implementing) of an interdisciplinary science curriculum. The curriculum is known by these three teachers (and not taught by the 4th). They share their inquiry ideas that their students develop the questions for, but otherwise their list of activities is pretty standard between the three classes.

Side note - Another interesting relationship I see happening here is how the team is collaborating to ensure that their students are meeting grade level expectations in reading because of the pressures they say they feel from the enactment of district and state policies, as a result of NCLB. This team has demonstrated how students reading needs are still met without the science curriculum having to suffer. They believe the key is for them, as a team, to have the same goals for their students overall learning; and to achieve these goals that they continue to collaborate and approach their teaching as a unit rather than individuals.

Appendix I

Essential Features of Classroom Inquiry and Their Variations

Essential Feature	Variations			
Learner engages in scientifically oriented questions	Learner poses a question	Learner selects among questions, poses new questions	Learner sharpens or clarifies question provided by teacher, materials, or other source	Learner engages in question provided by teacher, materials, or other source
Learner gives priority to **evidence** in responding to questions	Learner determines what constitutes evidence and collects it	Learner directed to collect certain data	Learner given data and asked to analyze	Learner given data and told how to analyze
Learner formulate **explanations** from evidence	Learner formulates explanation after summarizing evidence	Learner guided in process of formulating explanations from evidence	Learner given possible ways to use evidence to formulate explanation	Learner provided with evidence and how to use evidence to formulate explanation
Learner connects explanations to scientific knowledge	Learner independently examines other resources and forms the links to explanations	Learner directed toward areas and sources of scientific knowledge	Learner given possible connections	
Learner communicates and justifies explanations	Learner forms reasonable and logical argument to communicate explanations	Learner coached in development of communication	Learner provided broad guidelines to use sharpen communication	Learner given steps and procedures for communication

More ---------------Amount of Learner Self-Direction --------------- Less
Less ------------- Amount of Direction from Teacher or Material --------- More

Note. From *Inquiry and the National Science Education Standards: A Guide for Teaching and Learning* (NRC, 2000, p. 29).

VITA

Meredith A. Park Rogers grew up in rural Dresden, Ontario Canada, where she completed her elementary and secondary education. She received a Bachelors of Kinesiology from McMaster University in Hamilton, Ontario, and from there moved to Buffalo, New York to complete her elementary certification combined with a Masters of Science in Elementary Education from D'Youville College. Shortly thereafter, Meredith accepted a fulltime teaching position with Trillium Lakelands District School Board located in north central Ontario, known as "cottage country." She taught for two years in a grade 5/6 multi-age classroom in a small town named Cardiff.

Meredith completed her doctoral degree program from the University of Missouri – Columbia (MU) and is currently working as project manager for a state-funded professional development evaluation grant. During her five years at MU she taught several courses for the Undergraduate Teacher Development program and worked on various research grants in science and mathematics education. Dr. Sandra K. Abell was her program advisor and dissertation chair. They developed a strong collegial relationship over the years through various research and teaching experiences.

Outside of work, Meredith spends most of her free time with her husband of four years, Kevin Rogers. In July of 2006 they will move to Bloomington, Indiana where Meredith has accepted an assistant professor position in elementary education at Indiana University. Her future teaching and research foci will remain on improving the quality and quantity of science taught in K-6 classrooms.