CURRICULAR CONSTRAINTS, HIGH STAKES TESTING AND THE REALITY OF REFORM IN HIGH SCHOOL SCIENCE CLASSROOMS

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ABSTRACT

Jennifer Coble: Curricular constraints, high stakes testing and the reality of reform in high school science classrooms
(Under the direction of Dwight L. Rogers)

Through a series of open-ended interviews, this study investigated the beliefs of six third year high school science teachers about how they implement science education reform ideals in their practice and the contextual challenges they face as they attempt to implement reform. The teachers argue that the lack of connection between their curricula and students' lives serves as a significant obstacle to them utilizing more inquiry-based and student-centered strategies. In their science classes that are not subject to a high stakes exam, the teachers shared instances where they engage students in inquiry by reframing the focus of their curricula away from the decontextualized factual information and onto how the information relates to human experience. In their science classes subject to a high stakes test, however, the teachers confessed to feeling no choice but to utilize more teacher-centered strategies focused on information transmission. This study provides an in depth analysis of how the presence of high stakes tests discourages teachers from utilizing reform based teaching strategies within high school science classrooms.

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TABLE OF CONTENTS

CHAPTER ONE
INTRODUCTION

Science education reform initiatives (AAAS, 1990; NSTA, 1991; NRC, 1996) insist that our increasingly scientific and technological world demands that all citizens be scientifically literate. Reform efforts have articulated a vision of scientific literacy that goes beyond the acquisition of disparate facts and figures. Scientific literacy is defined as the understandings and habits of mind individuals need to become compassionate human beings who can use scientific information to make decisions that face them every day as well as those that will face our world in the future (NRC, 1996). Reformers insist that the goal of scientific literacy requires a new approach to science education. Instead of teachers presenting information and covering science topics, students should be discovering such information on their own through inquiry. Reform initiatives emphasize the importance of students negotiating their understandings of science with their teacher and peers, asking questions about the nature of our world, collecting information, constructing explanations and communicating their explanations with others.

While reformers insist that science teaching should be inquiry-based and conceptually focused, the dominant paradigm in secondary science teaching continues to limit teaching to transmitting information to students, learning as acquiring information, and assessment as a summative measure of the degree to which this information is retained (Gallagher, 1991; Tobin, 1994; Weiss, Banilower, McMahon, & Smith, 2001). Lecture-discussion, with occasional demonstration are pedagogical staples within most high school science classrooms

in which the primary focus is often on covering a large amount of factual material. Thus, the science teaching methods occurring in the vast majority of secondary science classrooms are the methods that reformers argue against.

The lack of impact reform efforts have had on the nature of science teaching is particularly frustrating for science teacher educators who focus on providing teachers with the ideas and skills they will need to implement reform (Anderson & Mitchener, 1994; Brunkhorst et al., 1993). Research has revealed that the progressive pedagogies supported within teacher education programs are often not implemented when teachers begin teaching (Wideen, et al., 1998). Research examining why beginning teachers do not adopt reform-based practices focuses on several different issues. Some studies conclude that beginning science teachers lack the necessary content knowledge and knowledge of the nature of science needed to design inquiry-based experiences for students (Carlsen, 1991; Tobin, 1994). Other researchers conclude preservice teachers hold firmly set beliefs that teaching is the mechanistic transfer of information and that these beliefs are difficult to change within a short teacher education program (Aguirre & Haggerty, 1995; Benson, 1999; Lortie, 1975; McDairmid, 1990; Pajares,1992; Rusk 1994; Stofflett, 1994; Stofflett & Stoddart, 1994). Finally, detailed accounts of individual teachers who struggle (e.g., Schmidt & Knowles, 1995) suggest these teachers have personal characteristics (e.g., unassertiveness, compliance, shyness) that inhibit them from succeeding as a teacher. All of this research is characterized by a focus on the teacher, his or her personal characteristics, beliefs, and knowledge, connecting the nature of classroom practice to specific qualities of the teacher. Gitlin (1990) argues, however, that this narrow focus within research on teaching is related to society's assumption that school problems can be fixed by changing what teachers do. He insists that

this idea fails to acknowledge the social, relational and interactive nature of teaching. The critical view of teachers, he maintains, has arisen out of educational research that prioritizes the interpretations of researchers over those of teachers. When researchers participate in research, they assume to have a better understanding of the incidents within a classroom and often fail to acknowledge or ask for the teachers' understandings.

I support the idea that if teachers are going to be responsible for implementing the visions of reform set forth in the *National Science Education Standards* (*NSES*) (NRC,1996), they must have a legitimate role in developing knowledge about reform (Keys & Bryan, 2001). As Clandinin and Connelly (1992) argue, "teachers are not mere screens who translate others' intentions and ideologies into practice" (p. 669). They insist that those concerned with improving education need to be concerned not only with what it is they wish to happen in learning but also with teachers' knowledge and the contexts in which they work. Inspired by feminist conceptions of knowledge and research, this study explores the narrative accounts of six beginning teachers who graduated from their teacher education program voicing strong intentions to teach in a reform-based manner. Through a series of open ended interviews, I invited the third-year teachers to share the challenges they face as they attempt to enact reform ideals and describe how these challenges influence the extent to which they are able to implement reform-based strategies within their classrooms. Therefore, my study was guided by two main research questions:

- How do the science teachers see the ideas within science education reform shaping their teaching?
- What contextual factors and early teaching experiences do the teachers see as influencing the extent to which science education reform impacts their current teaching?

In addition to providing descriptions of teachers' experiences as they attempt to enact reform ideas, I sought descriptions of reform-based strategies the teachers have designed for their students, acknowledging the essential role teachers play in developing models of reform-based teaching that are relevant to their students and contexts. Reform documents serve as an inspiration, challenging teachers to pursue progressive goals. The teacher, however, will be the ultimate decision maker on what is best for his or her students.

Chapter descriptions

This chapter serves to introduce the reader to the main focus of this study, the factors that prompted the development of my research question as well as some of the theoretical frameworks underpinning my research. In the next chapter, I situate my study within the literature on science education reform, beginning teacher practice and the current contexts of secondary science classrooms. A discussion of the research methods I used to collect and analyze my data is the focus of Chapter III. My findings are discussed in Chapters IV and V. In Chapter IV, I share the teachers' accounts of their early experiences attempting reform-based strategies in their classrooms and how these experiences highlight the critical role of the curriculum in achieving reform ideals. I also discuss the various ways teachers reframed the content of their curriculum through inquiries into real life issues and events. In Chapter V, I explore how high stakes tests have discouraged teachers from acting on their reform-based goals. I provide a detailed exploration of how and why the presence of these tests prompts teachers to teach in ways that go against their beliefs of what is best for their students. Chapter VI provides a summary of research conclusions as well as a discussion of how my findings contribute to the literature on beginning teachers and science education reform. I also examine the implications my findings have for science education reform,

science teacher education and teacher research. Furthermore, I explore the implications testing is likely to have on students' abilities to participate in our democracy. Finally, I provide a discussion of the limitations of my study, my recommendations for future research and a reflection on the how my dissertation has contributed to my personal and professional learning journey.

CHAPTER TWO
CONNECTIONS TO THE LITERATURE

Introduction

In the previous chapter, I shared how science education reform efforts appear to have had a minimal impact on the nature of science teaching occurring within secondary science classrooms despite the efforts of reform-based science teacher education programs. I also presented a critique of the research exploring why beginning teachers fail to enact reform ideals. I highlighted the lack of teacher voice and the lack of attention to contextual influences. Finally, I discussed how my study focuses on providing beginning secondary science teachers a voice to share how they are able to implement reform and how their classroom contexts influence the extent to which they are able to implement the ideals of reform.

In this chapter, I review the literature that informed the development of my study as well as the literature that informed my understanding of the major themes within the teachers' narratives. I will first discuss the major science education reform initiatives. Then I will discuss research exploring why these reform efforts have had such a limited impact on secondary science teaching. As I did in Chapter 1, I will argue that much of the literature examining why teachers fail to implement reform does not address the significant challenges presented by the current contexts of schools. I then explore research highlighting the significant impact high stakes testing is having on teachers' ability to utilize reform-based

strategies. Finally, I use the ideas of critical science educators and Dewey to highlight the role the curriculum plays in teachers' ability to implement reform.

History of science education reform

Science is the *process* of questioning our natural world and seeking solutions to human problems. Science is also a *body of knowledge* produced through the collective scientific endeavor, which has identified, symbolized and quantified nearly all natural phenomena. Given the enormity of this body of knowledge and the skills required to produce it, the dilemma over what science should be school science has been and continues to be a source of debate. An inquiry into the history of science education in the United States will reveal wave after wave of reform movements (DeBoer, 1991). The goals for science education founding these multiple reform initiatives have swung like a pendulum between two opposing views on what science should be school science.

Events that highlighted the importance of scientific advances to our international competitiveness, like World War II, the Soviet launch of Sputnik and the educational "crisis" of the 1980's, swayed reform initiatives toward support for school science as protecting our national interests. In these times, the focus for science education was on preparing youth to become scientists who would advance the frontiers of scientific knowledge. From this perspective, science education should be rigorous and focus on the scientific knowledge behind important scientific research endeavors. During these reform efforts, the core of the subject matter took precedence over that of its application and connection to everyday life.

Alternatively, when more attention was focused on youth development than national interests, school science swayed toward meeting the interests and needs of all students. This occurred early in science education's presence with the Progressive Education Movement of

the 30's and 40's, during the strife of the late 1960's and 1970's with the Humanistic Education Movement (DeBoer, 1991). During these times, reform was lead by individuals who saw that school science should prepare individuals to utilize science for improving their own lives and coping with an increasingly technological world. Under this motivation, school science was to be presented in relation to important aspects of contemporary life. In these times, the science knowledge related to real life issues and human concerns took precedence over the core of the subject matter.

Reform initiatives of the 1990's

In the last 15 years, a great deal of time and effort has been directed toward defining the knowledge citizens need to be involved in our increasingly scientific and technological world, resulting in the creation of three major reform initiatives (AAAS, 1990; NSTA, 1991; NRC, 1996). The American Association for the Advancement of Science (1990) published *Science for all Americans*, which establishes a set of recommendations for the understandings and habits of mind essential for all citizens in a scientifically literate society. Scientific literacy is defined as the scientific understandings and habits of mind needed to use scientific information to make personal choices that arise everyday and to engage in discourse and debate about important issues that involve science and technology. Furthermore, scientific literacy is valued for the affective dimension of scientific understanding as everyone deserves to share in the excitement and personal fulfillment that come from understanding the natural world. *Science for all Americans* recommends that science education focus on major, overriding concepts and scientific principles and that students should learn by engaging in scientific inquiry.

One year later, the National Science Teachers Association (1991) published their recommendations in a document titled, *Scope, Sequence and Coordination*. Much like *Science for all Americans*, this document recommends that science education focus on unifying scientific themes and science related issues, not disciplines and topics. It also emphasizes the importance of students learning science through inquiry and investigation and the importance of science education focusing on science topics that are connected to students' lives. In 1996, the National Research Council (NRC) published the *National Science Education Standards* (*NSES*) outlining what students need to know, understand and be able to do to be scientifically literate. This was the major methods course text for the teachers' who are the focus of this study. The *NSES* argues that science education should focus on providing students the science knowledge they will need for making personal decision as well as collective decisions about science related issues our world faces and will face in the future. It contends that the goal of scientific literacy demands that students actively participate in their learning through asking questions, collecting data, assessing information, constructing explanations and communicating their understanding with others. *NSES* demands a shift in emphasis from teachers presenting information and covering science topics to students discovering such information on their own through inquiry.

Defining inquiry and scientific inquiry

The *NSES* states that, "inquiry into authentic questions generated from student experiences is the central strategy for teaching science" (1996, p. 31). The traditional form of scientific inquiry, cookbook lab where students are told what to do at each step and where the conclusions are know ahead of time, is criticized as supporting an incorrect vision of the nature of science. The *NSES* argues that students should learn about science as scientists

study science and that science education should assist students in the formulating questions, designing experiments, collecting scientific data, analyzing this data for trends, drawing conclusions and developing rich explanations that justify and extend their evidence. Many science educators, however, question the value of defining inquiry by the methods practiced by scientific researchers, arguing for a broader vision of inquiry that is more realistic to school contexts and more aligned with the forms of inquiry individuals use in their everyday lives (Fradd & Lee, 1999; Hinman, 1999, Seiler, 2000; Songer, 2002, 2003). I use inquiry-based learning in this dissertation as defining the approach to science learning where science understanding is developed through students pursuing answers to questions. Through inquiry, students actively build explanations of scientific phenomena and science related issues, integrating their current understandings with the scientific conceptual understandings. Particularly, inquiry-based learning emphasizes a view of science as preparation for life and scientific knowledge as productive information used to solve real world problems (Hurd, 1997).

The current status of science education reform

In 2000, the National Science Foundation supported a national survey of 5,728 science teachers (Weiss, Banilower, McMahon, & Smith, 2001). The survey focused on assessing what teachers are trying to accomplish with their instruction and what activities they use to meet these objectives. In addition, the survey investigated the extent to which teachers support the reform notions embodied in the *NSES* (NRC, 1996). The resulting report reveals significant insight into the role reform initiatives are playing in schools. Overall, the report concludes that teacher implementation of the *NSES* in high school classrooms is minimal and related only to the use of laboratory activities. While teachers did

implement laboratory exercises, these activities are not student-centered as reform initiatives recommend, but involve students following specific instructions. Teachers who report that they implement the *NSES* were not likely to use other teaching composites supported by reform initiatives such as projects/extended investigations, informal assessment, journals/portfolios or strategies to develop students' ability to communicate ideas. The data reveal that traditional pedagogical practices, such as whole class lecture, individual student reading textbooks and completing worksheets continues to dominate the majority of time in science classrooms.

Related to assessment, seventy-nine percent of teachers report that they predominately use short-answer tests (composed of multiple choice and/or true/false questions) to assess student learning while less than a quarter report using student portfolios or long term science projects. Such an assessment focus on lower order content retention and the lack of more authentic assessment strategies is directly opposed to the recommendations made within the reform documents. These findings reveal that the reform initiatives have had little impact on the ways that students are learning and experiencing science. Exploring why reform efforts have resulted in so little change is the million dollar question within science education research and is the broad focus of this study.

Science education reform and science teacher education

Science teacher preparation is now recognized as the pivotal point in the reform of science education (Brunkhorst et al., 1993). Science methods courses involve pre-service teachers in discussions about the limitations and faults of traditional teacher-centered pedagogies. At the same time, the preservice teachers learn about reform-based models of science teaching and are required to design lessons that implement them. Therefore, much of

the research exploring the impact of reform on teaching is concentrated on beginning teachers who leave programs focused on reform. This research has revealed that the progressive pedagogies supported by teacher education are often not implemented once the teachers begin their work in the classroom (Benson, 1999; Carlsen, 1991; McDairmid, 1990; Pajares, 1992; Rusk, 1994; Wideen, et al., 1998; Zeichner and Tabichnick, 1985).

There is great interest in examining why pre-service teachers, who leave their teacher education programs voicing strong desires to utilize reform-based teaching methods, implement the same traditional teaching pedagogies they criticized within their university classrooms. Teacher socialization studies indicate a progressive to traditional shift in professional perspectives when beginning teachers acquire their own classrooms (Pajares, 1992; Wideen, et al., 1998; Zeichner and Tabichnick, 1985). That is, students tend to be progressive and liberal in their attitudes toward education as they progress through their preservice program and then shift to more conservative, traditional views of teaching when they assume responsibility for their own classrooms. In their field experience and their first year of teaching, a conservative, practical mind set toward teaching quickly develops. Zeichner and Tabichnick (1981) argue that the effects of teacher education are "washed out" by school experience.

Researchers have come to various explanations for this “wash out” phenomenon. While different researchers have offered different explanations for the specifics of how this reversal in teaching view occurs (Pajares, 1992; Benson, 1999, Carlsen, 1991), Lortie’s (1975) “apprenticeship of observation” theory is commonly cited. Lortie argues that teachers’ experiences as students, where they were exposed to predominantly conservative models of teaching, have a powerful effect on teachers’ beliefs. These strongly held beliefs

are believed to minimize the influence that teacher education can have. Support for this conception can be seen by the focus within teacher education programs on challenging and, ultimately, changing the beliefs of pre-service teachers (Stofflett, 1994; Stofflett & Stoddart, 1994; Aguirre & Haggerty, 1995). McDairmid (1990) concludes that when preservice teachers "appear to reconsider their beliefs, such changes may be superficial and short lived" (p. 12). Similarly, Rusk (1994) concluded that when beginning teachers are confronted with the realities of the classroom, they revert back to their deeper belief systems.

The research described above reveals that the influence of teacher education courses is marginal, concluding that beginning teachers' firmly set beliefs about teaching are difficult to change. Other research has concluded that beginning science teachers lack the necessary content knowledge or knowledge of the nature of scientific inquiry needed to design inquiry experiences for students (Carlsen, 1991; Tobin, 1994). The research examining why beginning teachers fail to adopt reform-based practices, is characterized by a focus on the teacher, his or her beliefs, and knowledge repertoire. In his review of research on teacher beliefs, Pajares (1992) concludes that, "students become teachers, unable, and subconsciously unwilling to affect a system in need of reform (p. 322)". This conclusion within a well cited review highlights the responsibility educational researchers have placed on teachers for the problems they see in classrooms.

A critique of research on reform

Gitlin (1990) argues that the criticism of teachers within educational research is related to society's mentality where school problems can be fixed by changing what teachers do. He insists that such a view fails to realize the social, relational and interactive nature of teaching. He supports that teachers become one of the major targets of blame for problems

that more accurately reflect the priorities and failings of our economic system, which place teachers under unrealistic contexts. He explains that the critical view of teachers has arisen out of educational research that prioritizes the interpretations of researchers over that of the teachers who experience the classrooms. When researchers participate in research, they assume to have a better understanding of what transpires in the classroom and often fail to acknowledge or ask for the teachers' explanations for why they do what they do. In this way, research becomes a one way process that is done to the teachers, and the researcher is not able to benefit from the teacher's personal knowledge and understandings of his or her practice (Gitlin, 1990).

I, like Gitlin, am critical of the body of research examining why teachers fail to implement reform recommendations, particularly the deficit view of teachers that is often portrayed. Zeichner and Gore (1990) refer to this research tradition within teacher research as the functionalist paradigm. The functionalist paradigm is concerned with explanation, assuming the observer's or researcher's point of view. Research within this tradition attempts to, "relate what *they* observe to what *they* regard as important elements" (p. 330). Much of the research is based upon surveys, questionnaires and structured interviews. Therefore the nature of the data researchers elicit from teachers and, in the end, the nature of the connections they make is based upon their own assumptions. Another tradition in teacher research is the interpretive paradigm (Zeichner & Gore, 1990). The interpretive paradigm aims at developing understanding of experiences from the participant's point of view rather than the observer's or researcher's. This study exist within the interpretive paradigm, designed out of the belief that research into science teaching and reform must give teachers the voice to explain why they teach the way they do.

The role of teachers' knowledge

At the heart of this study is a recognition that teachers who attempt to teach in a reform-based manner will face significant challenges. Furthermore, these challenges will influence teachers' ultimate classroom practice. In addition, this study is based upon the recognition that teachers' conceptions of what their practice should be will be determined more by their experiences in the contexts of their schools and classrooms than by the ideas supported in their university classrooms. Support for such a view of teacher's knowledge comes out of research within the interpretive paradigm, (Zeichner and Gore, 1990, Clandinin & Connelly, 1995) which emphasizes teacher's ideas, experiences and resulting narratives. Donald Schon (1987) has concluded that the knowledge of a professional is knowing-in-action, which is tacit, spontaneous, subjective and context bound. Thus, he insists that teachers' knowledge is experientially based and developed through reflection on classroom experiences. Such a view of learning recognizes that learning to teach is fundamentally a private enterprise in which the teacher must grapple with pedagogical decisions within the constraints of their teaching context. Specifically for teaching, Schon, highlights the importance of teachers being able to respond to the unique needs and actions of each of their students.

Clandidnin and Connely (1995) support a similar view of teacher knowledge. Their conception of teacher knowledge, which they refer to as personal practical knowledge, highlights the role of teachers' past experiences in their future plans and actions. They support that teachers' life experiences significantly influence how they view their role as a teacher and how they organize their practice insist that it is impossible as traditional research

suggests to understand teaching by observing a classroom. An understanding of teaching demands knowledge of the complex environment in which it occurs.

Connelly, Clandinin and He (1997) discuss how theories, philosophies and ideologies lead to policies. It is assumed that these policies and guidelines will automatically translate into classroom teaching practices and, thereby, to student learning. Their research, however, emphasizes that teachers use their own selves and stories to dramatically modify the policy guidelines given to them. They contend that, "teachers are not mere screens who translate others' intentions and ideologies into practice" (p. 669). They insist that those concerned with improving education need to be concerned not only with what it is they wish to happen in learning but also with teachers' knowledge and the professional knowledge landscapes in which teachers work.

It is clear that teachers' actions are influenced by many factors including their students' beliefs and actions, those of their colleagues and administrators, and their school's contexts and policies. Therefore, it is possible that the strong emphasis educational research places on teacher's beliefs as the major factor influencing teacher actions is misguided. It is also possible that the ideas teachers leave their university classrooms with are not "washed out" as researchers have suggested, but are mixed in with all of the competing demands of teaching in today's schools. The research literature has not addressed the complexity of issues involved when new teachers attempt to act on visions of reform. In the rest of this chapter, I discuss literature highlighting the challenges the current contexts of schools offer to reform-based teaching. First, I discuss research examining the influence of high stakes testing on teachers' classroom practice. I then explore the arguments of critical science educators who address how the traditional conceptions of school science marginalize

students from engaging in science in the ways supported by science education reform. Finally, I discuss the ideas of Dewey (1902, 1916, 1938) as many of his writings address the tension the teachers in this study face between meeting the needs of their students and meeting the demands of their mandated curricula.

Reform and contextual challenges

An understanding of the reality of inquiry-based learning in high school settings from a teacher's point of view remains elusive (Keys & Bryan, 2001). Most research exploring reform-based teaching has been conducted in privileged settings where teachers experience a high level of autonomy, plentiful resources and support from administrators and colleagues (Songer, 2003). Furthermore, most research on inquiry has been performed in elementary and middle school settings (Keys & Bryan, 2001). Therefore, "the field remains somewhat uniformed of the challenges of implementing inquiry science programs across a range of classroom settings and learners" (Songer, 2003, p. 491).

The few studies that have explored challenges to inquiry within the traditional contexts of high school science classrooms have revealed that teachers experience tension between allowing students to pursue their own questions while also ensuring that students are developing an understanding of the concepts contained within mandated curricula (Baumgartner, 1999; Songer, 2003; Tabak & Reiser, 1999; Wollweber, 1998). The 2000 National Survey of Science and Mathematics (Weiss et al, 2001) reveals that school accountability policies, which have become widespread since passage of *No Child Left Behind* (2001), are perceived by teachers as one of the most significant challenges they face to implementing the ideals within *NSES*. The report revealed that only 39% of high school science teachers feel they have control over determining the content, topics or skills to be

taught in their classrooms. Interestingly only 18% of science teachers in the southern region of the U.S., where the teachers in this study teach, report that they have control over determining the content and skills to be taught in their classrooms. In Chapter 5, I discuss how the pressure teachers are under to prepare students for high stakes tests discourages them from acting on their reform-based beliefs. In the following section, I discuss research that has examined how high stakes testing has impacted classroom practice, particularly secondary science teaching.

The most informative study revealing the impact of high stakes testing on secondary science instruction is outlined in McNeill's (2000) *Contradictions of School Reform*. The original intent of this study was to document how an innovative magnet school was able to provide authentic, engaging teaching and learning for Houston's inner city youth. During the study, however, the school, which had previously been free of state mandates such as state adopted texts, state mandated curricula and high stakes testing, was forced to comply with the centralized rules. McNeill's book describes the sweeping effects the implementation of mandated curricula and high stakes testing had on the once innovative and reform-based school. Overall, McNeil describes how a "phony" curriculum began to emerge presented by reluctant teachers who conformed to the knowledge that the students would encounter on the standardized tests. She shares how the mandated list of proficiencies transformed the curriculum into a highly reductive and fragmented list of ideas that countered the teachers attempts to support students' ability to make connections and apply what they were learning to new situations. The mandated curriculum separated the content of classroom learning from the knowledge of the teacher and from the knowledge and interests of the students.

Research has revealed that high stakes tests often determine what content is taught as well as the nature of the content that is taught. First, the content that is prioritized on the test receives priority in the classroom while content that is not prioritized is often omitted from classroom instruction (Brown, 1992**;** Herman & Golan, 1992; Johnston, 1998; Koretz, 1995 **;**McNeill, 2000; Rottenberg and Smith, 1990; Shepard, 1991, 2000)**.** Second, since multiple choice test questions often assess lower level factual information over application and interpretation, the test has prompted a teaching focus on the highly reductive and fragmented factual information that correlates with test items (Calder, 1990; Madaus, 1991; McNeill, 2000; Rottenberg and Smith, 1990; Shepard, 2000; Wideen, 1997). In McNeill's (2000) study, teachers maintained that science classes had become content oriented but they and had been reduced to little more than the presentation of a string of facts to be memorized for the final examination. The nature of the content switched to more "objective" information (terms, processes, etc.), replacing the more interpretive (debates, ethical issues), analytical (scientific inquiry, dissections, independent research) and the notion of an origin of the information (social context of scientific discoveries, nature of science, etc.).

In addition to having a significant impact on the focus of the content in the classroom, testing has significantly altered the instructional methods teachers use. McNeill (2000) found teaching shifted from models of authentic intellectual activity to the dispensing of information with a significant reduction in the role of students as contributors to classroom discourse. State-mandated testing has been found increase the amount of time spent lecturing, testing, and reviewing with less time spent on creative projects, cooperative learning activities, laboratory experiments, library research, and field trips (Romberg et al. ,1989; Rottenberg and Smith, 1990; Samiroden, 1990).

McNeill (2000) found that teachers reduced the amount of experiential learning they used as the nature of understanding the students learned from these inquiry experiences did not align with how the concepts were tested. She shares the story of a teacher who strives to connect the physical science concepts in her curriculum to students' real world experiences. To help students understand the relationship between mass, inertia and work, she shows a video of car safety crash tests and asks students why the smaller car is totaled while the larger car is merely dented. While the main concepts involved in this real life event (mass, weight, gravity, inertia, etc.) are covered on the test, they are presented as vocabulary terms to memorize and are often tested for what they are not: "Which of the following is not true of gravity?" In the test questions, the science concepts are not encountered as phenomena that are experienced, observed or explained (McNeill, 2000). Therefore, the teachers were reluctant to focus on the real life nature of the information since such a focus would not prepare students for the questions on the test. The literature on high stakes testing has revealed how the pressure to teach to the test prompts teachers to focus on the basic factual information at the expense of how this information relates to real life. For critical science educators, this exclusion of lived experience from the science curriculum is seen as responsible for marginalizing many students from science, particularly minority and poor students. In the following section, I discuss how these science educators offer insight into the ways science education can be reformed for scientific literacy to be a reality for more students.

Science for *all* or science for some?

The *NSES* (NRC, 1996) insists that "science is for all students" and "emphatically reject any situation in science education where some people are discouraged from pursuing

science and excluded from opportunities to learn science" (p. 20). Many science educators argue that science education reform has failed to raise questions about what knowledge counts most, for whom, and for what purposes (Atwater, 1996; Barton, 1998; Cole, 1998; Lee, 1999, Micheals & O'Connor, 1992; McBane & Yager, 1996; Rodriguez, 1998; Seiler, 2000). These science educators insist that traditional science curricula are based on white, middle class desires and goals while the needs of many students are being excluded.

Cobern (1995) argues that scientific literacy will ultimately fail because the scientific conceptions, as interpreted in many high schools and colleges, hold little scope for most student's lives and, therefore, little influential meaning on their day to day thinking or worldviews. The growing abstraction and complexity of science classes in high school has been linked to students' negative attitudes and lack of self efficacy toward science (Piburn & Baker, 1993; Weaver, 1998). Barton (2001) discusses how the narrowly defined science within schools is so separated from the context of personal experience that students do not see how the skills and knowledge they acquire in school have currency outside of school. Therefore, students fail to see school science as relevant to their goals. She argues that the silencing of scientific knowledge that does not fall in the realm of recognized school science has resulted in the exclusion of certain populations toward the learning of formal science. Similarly, Brickhouse (1994) has argued that narrowly defined scientific ways of knowing such as rational thinking separated from feeling and emotion, and ideas separated from context and experience are particularly problematic for female and minority students who do not see their worldviews reflected in school science.

Critical science educators argue that opportunities to practice 'real science' are not likely (alone) to increase the chances that students will want to or be able to use academic

science in their lives beyond school (Eisenhart et al., 1996). If science is to be relevant to all learners, students should gain "a sense of science as something that is important to their lives and their community outside of school" (Eisenhart et al., 1996, p. 271). Rather than engaging students in a preconceived notion of science, critical science educators are finding ways to expand the boundaries of school science where science can emerge from the life experiences, questions and interests of all learners (Atwater, 1996; Barton, 1998b; McBane & Yager, 1996; Rodriguez, 1998).

Deweyan insights into science education reform

Traditional school science is based on the idea that science education should provide students with the accumulated scientific understandings, emphasizing certain facts and concepts deemed essential to current research endeavors. Dewey (1916, 1938) had a different vision of knowledge. Instead of an accumulation of information, Dewey saw knowledge as the accumulation of wisdom for solving problems. He viewed that humans are naturally and innately guided toward solving the problems of experience. He emphasized how the accumulation of knowledge that has been produced through the history of mankind has developed out of this drive to solve human problems. This fact, he insisted, should drive pedagogy. He emphasized the importance of students understanding both the place and meaning of the subject matter within the organization of human experience. Dewey (1938) argued that teachers should not present already established truths via lecture but structure classes so their pupils could identify genuine problems. Through solving these problems, Dewey argued, the students would need to use the curriculum and, as a result, establish personal connections with the subject matter. Therefore, Dewey's view of education aligns

with those of critical science educators who insist that school science should emerge from the real life issues within students' lives.

Specific to science, Dewey (1916) argued that, "the mass of pupils are never going to be scientific specialists" (pg. 258), but students should be familiar with scientific methods of inquiry as a way of solving everyday problems. He cautioned against science education focusing on the basic, factual information supporting that "the few who do go on to be scientific experts will have a better preparation than if they had been swamped with a large mass of purely technical and symbolically stated information" (pg. 258). According to Dewey, the time "is more than made up for in the superior understanding and vital interest secured" (p 258). Therefore, Dewey warned about the danger of schools focusing on the "purely technical and symbolic" aspects of science as he believed these aspects of science would not foster the scientific understandings and attitudes students would need in their everyday lives. Since science education reform initiatives are focused on providing *all* students with the knowledge and skills they will need to live productive, thoughtful lives, Dewey's ideas are particularly relevant to current reform endeavors.

Conclusion

In this chapter, I discussed the main aims of science education reform as well as research highlighting how these efforts have had little impact on the nature of science teaching within classrooms. I also discussed the theories explaining why beginning teachers continue to utilize traditional teaching strategies despite their involvement in teacher education programs committed to reform. I argued that the focus within this research fails to address the importance of how teachers' practice is influenced by students and school contexts. I reviewed research examining challenges to reform-based teaching, particularly

the influence high stakes testing is having on classroom practice. I explored how critical science educators understand the nature of reform and highlight Dewey's insight into science teaching and learning. In this discussion I also explored views of teaching that highlight the experiential knowledge of teachers and the impact that contexts have on how a teacher develops his or her practice. This literature supports the importance of learning more about teachers' understandings of reform and the challenges they face as they attempt to act on their reform-based ideas. In the next chapter I discuss the data collection and analysis methods that I used to pursue these essential understandings.

CHAPTER THREE
METHODS

Introduction

In this chapter, I will explain the methods I used to collect and analyze my data. First, I present background information on my relationship with the teachers and how I came to realize the importance of this study. Next, I discuss the theoretical principles underlying the study design and my decision-making during the data collection and analysis phases. Finally, I provide some biographical details on the teachers in the study.

Pilot study reflections

My motivation to carry out this study and the methods I chose to use emerged out of understandings I gained from a small pilot study I undertook in 2003. I will share my learning journey with you, starting from the beginning. For three years, I worked as a student teacher supervisor for high school science pre-service teachers, including the teachers involved in this study. Most of the lessons I observed within this role focused on delivering factual information from teacher to student. While many lessons included hands-on activities and short laboratories, they were teacher-centered, focusing on validation of content presented in classroom lectures, not student-centered inquiry into content. I never observed a class involved in the long term, student-centered inquiry projects reform initiatives support.

During the post-observation conferences I had with student teachers, I routinely challenged them to think about how they could modify their lessons in ways that allow for more student-centered inquiry. The student teachers usually offered a range of reasons for

their reliance on more teacher-centered methods, such as the influence of their cooperating teacher, poor behavior and low motivation of their students, as well as the necessity to cover the curriculum to prepare for end of course exams. While I would listen and nod my head, I did not see their excuses as valid. I acknowledged that there were challenges to implementing reform-based methods in today's classrooms, but I believed their implementation was possible. If the teachers were truly committed and willing to make the extra effort, I assumed their implementation would be successful. With these assumptions in mind, I designed a pilot study for my dissertation. The goal of the study was to explore the beliefs and experiences of reform-based teachers, who I believed had the commitment and drive necessary to utilize reform-based methods. I supported that an examination of these unique teachers' belief systems would help science educators understand what is really reformed in science education when reform is a reality.

Although it was difficult to find teachers who implemented inquiry based science in a consistent manner, I was able to identify five who taught in the area. I had rich conversations with these teachers about why they support inquiry based science and how their teaching practices have evolved over time. When asked why they believe they are unique in the way that they teach, there was a surprising consistency in their responses. All of them highlighted the importance of their school and classroom contexts, which were unique. Four taught at private schools and one at a local magnet school for academically gifted students. They shared how lucky they are to be able to design their own curriculum, to have administrator support for taking the greater amount of time inquiry-based instruction demands and for being free from high stakes tests.

Two of the teachers had worked in public schools before and confessed to not being able to implement inquiry in these classrooms to the extent they are currently able to. Their responses were not what I expected to hear. They highlighted the significant influence of classroom contexts and school policies on the successful implementation of reform-based teaching methods. These findings challenged my assumption that teacher's beliefs and efforts played the largest role in their different teaching practices

This early data prompted me to take a critical look at my beliefs about science teaching and reform. During this time period, I read Gitlin's critique of education research, which I discussed earlier. I could not deny my resemblance to the researchers his article criticizes. I was forced to face my assumptions related to reform-based science teaching. I assumed teaching in a reform-based manner was a matter of choice. I believed that the traditional, didactic way of teaching took less effort and that, while the teachers may believe in the promise of reform, they were not motivated enough to implement it. I judged the science teachers I encountered and came to my own conclusions about why they did what they did in their classrooms. Thus, I was giving my ideas legitimacy while denying it to theirs. My decision to focus on only reform-based teachers for my pilot study was based on these assumptions. I assumed that they were the only ones to help me understand more about the nature of reform. These realizations made it clear to me that I needed to interview the more 'traditional' teachers I had initially excluded.

I chose to interview a few student teachers I had supervised who were then in their first year of teaching. Many of them had demonstrated a high level of motivation to teach in a reform-based manner while in the teacher education program. I was curious to see how

their experiences in their own classrooms had influenced their ideas about reform-based teaching.

The conversations I had with these teachers were truly eye-opening. It was obvious during our discussions that they have a deep understanding of the methods and motivations of reform. They shared how much they believe in the promise of reform for supporting more meaningful learning of science. They also expressed strong desires to be able to utilize these methods with their students, but had experienced failure when attempting to enact them in their classrooms. They confessed to facing overwhelming challenges when they attempted to implement reform-based teaching strategies. They shared how difficult it has been for them to get their students to come up with their own questions or participate in student-centered inquiry activities. They openly expressed their dismay and frustration at the lack of motivation their students demonstrated toward inquiry activities. They described feelings of bewilderment, since they believed that their students would be motivated and engaged, given the "right" style of teaching.

The teachers lamented about the challenges inherent in meeting the individual learning needs of as many as 150 students of varying ability and motivation, many of whom are completely passive in their classrooms. Finally, the teachers discussed the strong pressure they feel from administrators and other teachers to give the students the factual knowledge they will need for the end of course exams, reducing the time they have for student-centered projects. The teachers admitted to using teaching methods opposed to reform. They shared that they feel they have no choice but to use didactic teaching methods in order to keep students on task and cover the topics mandated in the curriculum. Many of them spoke to the difficulty of performing a style of teaching that is not how they would like

to teach, but feel they must. This was the greatest challenge they confessed to and the challenge they were not prepared for when they first began teaching. The teachers experience significant tensions as they attempt to reconcile their own ideas about the best way to teach with the ways they feel are demanded by their students, school policies and contexts.

I came into this study with the belief that changing science education relied on developing teachers who had a certain set of beliefs and abilities. My conversations with teachers challenged this belief. In addition, my eyes were opened to how I was discounting the teachers without understanding why they do what they do. I came to see how the science reform discourse, which I had been participating in, places blame on the current nature of science classrooms on teachers, without acknowledging the influence of their classroom contexts. These lessons motivated a change of focus for my dissertation. I wanted to be part of a discourse that values teachers' experiences, ideas and knowledge. These experiences motivated me to base this study on science teachers' ideas about and experiences with reform-based teaching in the contexts of public high school science classrooms.

My awareness of the injustices within the research on science education reform and how easily I participated in them has been the driving force behind the design of this study. I am eager to participate in a different research discourse that recognizes classroom teachers' knowledge as central to understanding reform in science classrooms. This study focused solely on high school science teachers, their ideas and experiences, which have been excluded from the current literature on science education reform. Given that this study aimed to illuminate previously silenced voices, my research methods were inspired by feminist conceptions of knowledge and research. In the following section, I will discuss

feminist epistemology and feminist research methodology as well as how I utilized these standpoints in my study.

Feminist epistemology and feminist research methodology:

Traditional conceptions of research are based on the belief that there is a body of knowledge or collection of truths that exist to be discovered. In addition, a researcher can discover the nature of these truths given the 'appropriate' research methods. Feminist scholars, however, strongly criticize traditional research and the 'knowledge' it generates (Nielson, 1990). Feminist epistemology argues that rational, objective thought is not possible (Reinharz, 1992). It insists that how one views and experiences the world influences how one comes to know the world (Duran, 1991). Thus, knowledge is particular to the knower and cannot be generalized to others. Furthermore, feminist scholars argue for the inclusion of multiple truths, particularly those perspectives that have been historically excluded from research (Alcoff & Potter, 1993).

Michelle Fine (1994) summarizes the influence of feminist epistemology on research in the following ways. First, it prioritizes the importance of experience and the role of the participant in what is known. Feminist epistemology recognizes the participants as the only experts and authorities on their reality**.** Second**,** since the participants are viewed as the authority of their experience, feminist methodology calls on researchers to avoid the traditional power hierarchy between researcher and participant. Changing this power relationship demands that researchers involve the participants significantly during the research process, particularly during the data analysis and interpretation stage. In addition, feminist research contends that all research is political in nature and should be directed toward societal change (Cook and Fonow, 1986). Feminist research emphasizes making

connections between individual experience and the larger social world in ways that highlight the need for change.

Since feminist epistemology emphasizes the importance of experience in knowledge and the existence of multiple realities and multiple truths, it emphasizes the role the researcher's personal and intellectual biography plays in how she perceives the people and contexts she studies (DuBois, 1983; Harding, 1987, 1992; Stanley and Wise, 1993). The fact that I have limited experience as a teacher and have spent the last four years embedded in studies of educational research and theory significantly influenced how I came to understand and frame the teacher narratives I gathered. However, my work as a high school science teacher struggling to implement reform-based methods within my own classroom offers me insight into the reality of the challenges. Feminist research is rooted in connection, collaboration and discussion between the researcher and participants, not data collection and analysis by the more "knowing" researcher.

In the next section, I will share my data collection and data analysis methods as the two are intricately intertwined. My data collection methods are designed to minimize the power differential between myself and the teachers, optimizing the teachers' ability to share their ideas and experiences from their own voice and perspective. The data analysis methods I used were also designed to preserve the participants' perspective and are guided by the voice-centered relational method (Brown & Gilligan, 1992). This research method is based upon relational ontology, which views people as embedded in a complex web of intimate and larger social relations, instead of the traditional western philosophy of a separate, independent, rational self or individual (Gilligan, 1982). The methodology focuses on

exploring individuals' narrative accounts in terms of their relationships to the people around them and the broader social, structural and cultural contexts in which they live.

A popular study exploring women's knowledge funds (Belenky, Clinchy, Goldberger, and Tarul, 1986) offers support for relational ontology, highlighting that women's ways of knowing tend to be highly contextual, with an emphasis on knowledge gained through interactions with others. I see this conception of knowledge, with its emphasis on learning by experience and through interaction, as particularly relevant to teachers' ways of knowing. Teaching is based upon relationships and a concern for others forms the foundation of the teacher-student relationship (Noddings, 1992). The relationships that teachers have with their students and the contexts they work within will play a significant role in how they come to understand their practice. Therefore, the voice-centered relational method is well suited for the goals of my study. In particular, my data analysis methods are designed around a version of the voice-centered relational method discussed by Mauthner and Doucet (1998).

Data collection:

This research study is based upon the belief that the only way to understand the current nature of science education reform is to focus on the ideas and experiences of those who we ask to be the agents of reform, the science teachers. Therefore, it focused solely on the ideas, experiences and feelings of a group of six high school science teachers who were in their third year of teaching. This study was guided by two main research questions:

- How do the science teachers see the ideas within science education reform shaping their practice?
- What contextual factors and early teaching experiences do the teachers see as influencing the extent to which science education reform impacts their current practice?

The data for this study consisted of transcripts from a series of three open-ended interviews, which were more akin to 'purposeful conversations' (Burgess, 1988) than interviews as well as a series of personal communications throughout the study. Each of these conversations had a slightly different purpose and focus. The first conversation focused on providing the teachers a space to share their ideas about and experiences with reform-based teaching methods. Particularly, I encouraged them to share the experiences and factors they see influencing the role that reform plays in their teaching. I did not enter into these interviews with a series of predetermined questions. Instead, I went with a series of topics to guide the discussion (Mauthner, 1998). This allowed the conversation to focus on the teachers' ideas and experiences in an open exploratory way rather than a linear, pre-determined fashion. Topics for these conversations included:

- their conceptions of and attitudes toward science education reform,
- the extent to which the ideas of science education influence their teaching,
- their experiences with implementing reform-based teaching methods and what they learned from them, and
- contextual factors that influence the role of science education reform in their practice.

During our conversations, I was diligent in asking the teachers to elaborate, share more examples and explore the meaning of their ideas and experiences for themselves and their practice. I was careful to not assume the significance of their contexts and experiences from my own perspective, but continually prompted them to reflect upon and share the meanings that they have assigned to them. Given the dialogic nature of our conversations, data interpretation was an ongoing and interactive process. During our conversations, if something they said sparked a connection in my mind to an earlier comment of theirs, a

theme emerging in the study or one within the literature, I would present my thought to them and ask them if they supported the connection. Therefore, during our conversations, I consistently presented my understanding of the significance of what they were saying to make sure my understandings were shared understandings. Feminist research prioritizes such in situ theorizing, where the research participants themselves are engaged in exploration of their realities and how they are influenced by outside factors (Wolf, 1996). The conversations with teachers were audiotaped and were the focus of the first cycle of data analysis. The first round of interviews lasted about two and a half hours and were conducted in December of 2004.

Data Analysis

As I shared above, the data analysis method I used for this study is based upon a particular version of the voice-centered relational method (Mauthner & Doucet, 1998). This method involves listening to transcripts three times with different goals for each review. The first review of the conversation is focused on two goals. First, it focuses on creating a log of the interview, identifying the main stories and ideas discussed. Particularly, I listened for recurring ideas, language, experiences and feelings. During this initial review, I created a data log paraphrasing the topics or stories as they transpired within the interview. This initial log become a reference for linking essential quotes or ideas that arose within the three analyses. The second goal of this reading was to assess how I responded emotionally and intellectually to the person and the text. This allowed me to examine how and when some of my assumptions and judgments might affect my interpretation of the teacher's accounts. These moments were noted and any questions about interpretations were included in the goals for the next interview with. By trying to describe how I was socially, emotionally and

intellectually located in relation to the teachers' ideas and experiences, I was attempting to, "retain some grasp over the blurred boundary between their narratives and [my] interpretation of those narratives" (Mauthner & Doucet, 1998: 127). Therefore, after the initial review of our conversation I created a data log that included my own thoughts and reflections as well as questions I wish to pursue in the following conversation.

The second time I listened to the transcripts I focused on how the participant feels and speaks about herself or himself throughout our conversation. I listened to their voices, views, emotions, and how they link meaning to the experiences they shared. As I listened, I transcribed specific quotes where the respondent used personal pronouns such as 'I', 'we' or 'you'. The emphasis for this analysis was on capturing how the respondents experience themselves within their broader contexts. As our conversations focused on their teaching experiences, this analysis allowed me to capture how the teacher spoke of herself or himself and the experiences they have had in their classrooms.

The third review of the tape focused on connecting the teachers' accounts within the broader social, political, cultural and structural contexts in which they live and work. I listened for instances when they alluded to broader context connections, such as school policies and culture, administrator attitudes, other teacher attitudes, student attitudes etc. I focused on why they alluded to these factors and how they connected them to their experiences and their teaching. In particular, given my interest in how the contexts of schools influence reform, I paid close attention to how the teachers perceived external forces to constrain and/or enable their personal intentions related to reform-based teaching. As in the other analyses, I took detailed notes on how the teachers refer to broader contextual factors, and compiled a list of connections I was making to pursue in the second interview.

After I listened to the tape three times, I compiled the themes and connections of each of the teachers, which became a case study. The case studies focused on their words, their realities and the connections they make during our conversations. Feminist research supports that unless research begins within the ordinary facts of lives, then the knowledge constructed will be "both alienating and apart from the actual experiences of human actors" (Andersen, 1994, p. 372). As I designed the study, I had initially planned to focus on the individual teachers separately at this time and postpone efforts to thematically aggregate the case studies (Patton, 2002). However, I realized that any effort to separate my analysis of individual teacher from the other teachers was a false separation. My mind naturally made connections between the teachers' accounts. Also, as my first conversations with teacher illuminated ideas and connections, these influenced how I approached consequent conversations with subsequent teachers. While I did create individual case studies for each of the teachers, I also began to compile a list of themes and connections that emerged from conversations with all of the teachers.

One of the main goals for the second conversation was to gather the teachers' perceptions of the validity and relevance of the themes within their individual case study as well as the major themes and connections that were emerging from the all teachers' accounts. I emphasized that, while these connections were based upon their dialogue, the purpose of our second conversation was to validate and clarify them. In addition to gathering feedback on the ideas represented in their case study, the second conversation explored the ideas and experience that arose during the first conversation in greater clarity, depth and detail. For most of the teachers, our initial conversation prompted them to think more about their ideas and experiences. Therefore, many of the teachers shared how they had thought more about

the topics we had discussed and how their ideas had evolved since our first conversation. The second conversation allowed me to delve deeper into the connections the teachers make between their practice and external influences such as the science education reform ideas, their curricula, their students, other teachers, their administrators and the various practices and policies of their schools. The second round of conversations was conducted in February and early March of 2005.

The second conversations were also reviewed three times in the same manner as before. I incorporated the new ideas, details and reflections within my original notes. Thus, notes from the second conversation were layered onto the first as the conversation topics connect. During my analysis of my second conversation, my attention shifted away from the teachers' individual case studies and more toward the overlapping experiences and themes. I was surprised by the congruency between the teachers' early experiences, their perceptions of their contexts and the ways they feel their contexts challenge their ability to implement the ideals of reform.

I support Gitlin's (1990) argument that research conclusions are valid only when they are developed within a mutual process between researcher and participant. Since my purpose in this research was to illuminate the teachers' ideas and not mine, it was essential that I ask for their reactions on the main themes that became the focus of this dissertation. Therefore, in the third and final conversation, I asked for feedback on how I planned to represent the broader themes I identified within and between the teachers ideas and experiences. While I had already gathered feedback on the representations included in their individual case study and their ideas on the broad themes that emerged from all of the case studies, the third conversation allowed me to explain what themes I was choosing to focus on within this

dissertation and how I was connecting these to their individual stories as well as to other ideas within the literature.

Before our final discussion, I sent each of the teachers a 3 page document containing a synopsis on the main ideas, themes and claims within my dissertation. I asked the teachers to consider the relevance of these ideas to their personal experience and to share with me which aspects seem most and least relevant for them. This allowed them to share their perceptions of the validity of the themes and representations I have presented, from their perspective.

The goal of reducing the power differential between researcher and participant, particularly giving the participant influence over how the study is ultimately interpreted and represented can create significant dilemmas for researchers and raise questions about the role of the researcher's voice in the study. As this dilemma is an essential distinction of feminist research, I will take some time to discuss it. Before, I shared feminist epistemology's central tenet that how one views and experiences the world influences how one comes to know the world (Duran, 1991). It is accepted within feminist research that researchers' interpretations of their data and how they represent the lives and experiences of the individuals they study is a source of knowledge. However, this knowledge is seen as specific to the contexts and realities of the researcher and not independent of the researcher who produced it (Duran, 1991). Thus, the feminist researcher "constructs what is actually a viewpoint, a point of view that is both a construction or version and is consequently and necessarily partial in its understandings (Stanley & Wise, 1993, p. 6)".

While feminist researchers acknowledge their viewpoint as a source of knowledge, they do not assume the generalizability of their knowledge and experiences to others.

Stanley and Wise (1993) emphasize the importance of researchers focusing on the processes by which they reach their understanding and conclusions as these are central to the knowledge that results from them. They contend that understanding is achieved through the researchers "frank presentation of the existence and management of different realities held by both the researcher and the researched (p. 89)." Both the researchers' and participants perspectives are sources of knowledge, specific to their own viewpoints, and should be included in the representations of knowledge gained from the study. Therefore, during our final conversation, I was diligent in making sure the teachers felt that their experiences are relevant to the main themes I connect them to.

The third conversations with teachers were conducted in April of 2005. As one of the teachers lived over three hours away and I was eight months pregnant, one of the final conversations was conducted over the phone, but I was still able to audiotape it. The third conversations focused mostly on the teachers sharing their ideas about how I was making connections to their experiences and teaching strategies. The teachers shared that they were pleased that I was planning on showcasing their inquiry based lessons. They were also pleased that I was providing a detailed description of the various ways high stakes testing impacts their ability to utilize reform. During our final conversations, I expressed my gratitude to the teachers for sharing their experiences with me and being so generous with their time. I was surprised by the gratitude the teachers expressed to me. All of them shared that it had been helpful for them to be able to share their experiences with me and see how the other teachers in their program were struggling with the same challenges they were. I became a way for them to learn how their experiences connected with the other teachers. They were also thankful that the story I was telling celebrated the instances when they have

successfully implemented reform while providing rich explanations for the factors that influence them to teach in more teacher-centered ways. While these conversations were supposed to be the final conversations, I continued to call and e-mail all them a couple more times to clarify an idea or ask for their opinion on something that arose later in the writing process. It felt very rewarding to have their support as I wrote up my ideas. This dissertation was a highly collective effort and was co-constructed with the teachers.

Teacher descriptions

This study focused on the ideas and experiences of six high school science teachers who were in their third year of teaching within public high schools. The teachers were all members of a one year master's level teacher education and certification program. This program had a clear and explicit focus on science education reform. Therefore, all of the teachers were taught that successful science teaching was that outlined in the various reform documents. I was the teaching assistant for both of their science methods courses and was the student teaching supervisor for all of the teachers during their internships. My supervision included eight class period observations with follow-up conferences as well as additional conferences at the teachers' request. Therefore, I have well developed relationships with these teachers and am familiar with many of the teaching goals they possessed when they graduated.

There were ten teachers in the 2001/2002 MAT cohort and nine were still teaching when I planned this study. I had three selection criteria I used to determine which teachers to invite to participate in the study. The first criterion is proximity. Luckily, eight of the teachers were currently teaching in North Carolina. A second criterion is teaching at a public high school. I am interested in exploring how the contexts of public high school science

classrooms influence science education reform. Therefore, I did not invite the one teacher who currently teaches at a private school to participate in the study.

The third criterion I used to select teachers is motivation to teach in a reform-based manner. Of the seven teachers who teach in public high schools within North Carolina, there are six who demonstrated a commitment to implementing reform-based teaching methods during their student teaching internship, while one of the teachers expressed little faith in reform-based methods and taught in a very traditional manner during her internship. Since my study focuses on understanding the challenges and successes of these teachers related to reform, I chose not to invite her to participate in the study. Therefore, I invited six of the teachers to participate in the study and all agreed. In the following section, I provide some descriptions of the teachers, their background experiences before teaching and a few comments about their portrayal of themselves as teachers.

Catherine

Catherine is a Caucasian women in her late 20's. She entered the MAT program immediately after she obtained her undergraduate degree in biology. She pursued teaching because she had always loved science and thought it would be a good career while raising a family. Catherine taught biology and earth science at a large high school surrounding a medium size city in the Appalachian mountains of North Carolina. She shared that her school lacked many resources and served a population of students from both suburban and rural areas.

Catherine's relationships with her students went beyond the realm of biology. She shared that she was a "surrogate mom" for many of her students. She described many instances where she provided advice and counseling to students who were facing difficulties

in their out-of-school lives. Unfortunately, Catherine left teaching after the first semester of her third year, and began working as a teachers' assistant at an elementary school. She indicated that she quit because she feared the stress she experienced trying to meet the needs of her students within the constraints of her high school was affecting her health. Catherine is currently a full time mom to her brand new baby girl. She plans to return to teaching in the future but not at the high school level.

David

David is an African American male in his mid-twenties. David knew he wanted to be a science teacher in high school as he loves science, especially biology, and loves talking about it. David emphasized the importance of respecting his students and building friendships with them. He commented that he usually has several students eat lunch with him in his classroom everyday. He is particularly committed to providing his African American students with a positive role model and hopes that his "nerdy" personality helps to break down some stereotypes his student may have about black men. David indicated that he holds high expectations for his students and is committed to helping them gain confidence in their ability to succeed. He shared that one of his goals was helping his students take more ownership of their learning and helping them to appreciate the value of knowledge. David's high school is one of the largest schools in the state and serves a suburban area surrounding a large metropolitan city in central North Carolina.

Diane

Diane is a Caucasian woman in her mid-twenties. She decided to become a teacher her senior year of high school and joined a state-sponsored scholarship program. After completing her degree in biology, she entered the graduate teacher education program to gain

licensure. Diane is the one teacher who only teaches biology (i.e. tested) classes. While Diane utilized a lot dissections and animal observation studies during her student teaching semester, she has not used any of these in her current classroom. Her department decided to omit animal dissections for the sake of providing more time for topics emphasized on the EOC. While she yearns to focus more on important world issues related to biology, she focuses on the factual information the students will need for the test.

Diane understands that her job is to teach the state mandated curriculum. Therefore, she tries to be satisfied with the occasional moments when she is able to talk about broader issues as they relate to course topics. She works within a highly ranked school serving an affluent suburban area. The last time I spoke with Diane, she had started her own business baking and designing wedding and party cakes and cookies. She will have taught the four years she committed to teach within a scholarship program at the end of this year. If her business grows, she plans to leave teaching.

Lucy

Lucy is a Caucasian women in her early 40's. Before joining the MAT program, she earned an undergraduate degree in biology and a masters degree in microbiology. She worked at a pharmaceutical company, conducting doing food and water testing for nine years until she had her two sons. When her sons were young, she worked as an assistant at their elementary school, which sparked her desire to enter teaching.

Lucy shared how much she enjoys engaging students in discussions over science. She emphasizes the importance of students actively talking about science ideas, building models and drawing pictures. She shared how she is particularly committed to helping students understand the science behind real world issues and the science knowledge they

need to take care of themselves and the environment. She believes that her experience as a mom of two adolescent boys helps her to relate to her students more. She shared that her classroom is always very loud and active as, "still, silent students are probably not learning." (Interview 1). Lucy's high school serves a suburban area surrounding a large metropolitan city in central North Carolina.

Matthew

Matthew is a Caucasian male in his late 20's. After earning his degree in biology, he worked as an assistant in an elementary school while he pursued his real passion, baseball, by coaching a local high school baseball team. His work with his players convinced him that teaching at the high school level was most appropriate for him. In addition to teaching earth science and biology, Matthew continues to coach baseball and football for his school. Matthew shared that his interactions with his students outside the classroom significantly influence how he teaches. Acknowledging that science is not a top priority for many of his students, he strives to make connections with his students, using movies, newspaper articles and research reports on a regular basis. He commented that his job is more about teaching his students to take responsibility for their work and learning than helping them learn a particular set of scientific ideas and theories. Matthew's high school serves a suburban and urban area within a large metropolitan city in central North Carolina.

Sarah

Sarah is a Caucasian women in her early thirties. After graduating with her degree in biology, she worked as a naturalist for a state park and a quality control for a pharmaceutical company. Her work as a naturalist sparked her interest in teaching. Sarah is particularly committed to helping her students become critical thinkers and be more aware of the way the

media distorts events for political gain. Sarah taught a upper level biology elective where she focused the entire class on human disease and current events. Sarah described herself as a "no-nonsense kind of teacher" that holds students to higher expectations than most of the teachers in her school. She shared how many of her students get upset with her, but she refuses to lower her expectations. While she knows she has the highest failure rate in her department, she supports that the majority of her students step up to the challenge and end up gaining more confidence in their abilities. Sarah's high school serves a suburban area surrounding a large metropolitan city in central North Carolina.

Conclusion

In this chapter, I discussed the experiences I had as I conducted my pilot study and how I came to understand how I was participating in the silencing of teachers by giving my beliefs about the nature of science education reform more legitimacy than theirs. This realization motivated me to pursue a study that would allow teachers to share their experiences with trying to act on the reform-based ideas they believe in within the contexts of their high school science classrooms. In the following chapter, I share the teachers' early experiences utilizing the reform-based strategies within their classrooms. This chapter explores the most significant challenges they faced and provides details of strategies teachers developed where they could act on their reform-based ideas while meeting the demands of their contexts.

CHAPTER FOUR

CONNECTING THE STUDENT AND THE CURRICULUM

Introduction

In my literature review, I describe the series of reform initiatives that have been published in the last fifteen years aiming to change the nature of science teaching and learning within schools (AAAS, 1990; NSTA, 1991; NRC, 1996). One of these reform documents, *The National Science Education Standards* (*NSES*)(NRC, 1996) was the course text for the teachers in this study. The *NSES* insists that students must learn science by engaging in inquiries that are interesting and important to them. It emphasizes active science learning and shifting the emphasis away from teachers covering information and toward students discovering the information for themselves. The teachers in this study graduated from a teacher education program focused on supporting teachers' ability to implement the reform ideals outlined in the *NSES*. In particular, the teachers who participated in this study were those who left the teacher education program voicing strong intentions to implement inquiry-based learning goals.

Research has revealed, however, that teachers often do not implement the models of teaching supported in their university methods courses and typically utilize more traditional teacher-centered models (Benson, 1999; Carlsen, 1991; McDairmid, 1990; Pajares, 1992; Rusk, 1994; Wideen, et al., 1998; Zeichner and Tabichnick, 1985). As I share in my literature review, however, I am critical of the perspective that much of this literature has taken. Like, Gitlin (1990) and Zeichner and Gore (1990), I support that this body of research

prioritizes the interpretations of researchers over that of the teachers and fails to address the contextual challenges to reform. This study, based upon feminist epistemology and feminist research methods, focuses on giving teachers a voice to explain why they teach the way they do. This study investigated beginning high school science teachers' practice from their perspective. Through a series of open ended interviews, I invited the teachers to share the challenges they have faced as they attempt to enact science education reform ideals and how both the reform ideals and these challenges shape their classroom practice.

My interviews with teachers reveal that the teaching goals and the teaching methods the teachers' support continue to be closely aligned with those outlined in the science education reform initiatives (AAAS, 1990; NSTA, 1991; NRC, 1996). While they share many ways their contexts present challenges to meeting these goals, the greatest challenge they face is the lack of interest most of their students demonstrate toward the curricula they are expected to teach. Therefore, the nature of the mandated curricula serves as an obstacle to engaging their students more actively in their learning and developing the attitudes and understandings essential for scientific literacy.

When teachers experience a sense of curricular flexibility, there are instances when they successfully reframe the content through a focus on real world events and issues. In these instances, the teachers break the traditional boundaries of high school science and engage their students in raising questions, making meaning with others and critically analyzing information. My study exposes how the presence of high stakes tests restricts teachers ability to reframe the content of their curricula and, instead, prompts teachers to utilize traditional teaching strategies despite their desire to do otherwise. In this chapter, I explore how the teachers came to understand the significance of the content of their

curriculum on their ability to engage their students more in their learning. I also discuss the teaching strategies the teachers develop to reframe their curricula in ways that prioritize the experiences and interests of their students.

Striving to teach the science of life

Secondary science teachers have been found to prioritize a focus on the acquisition of the basic concepts of the curriculum because their personal appreciation of science supports the belief that the information is inherently interesting and valuable (Tobin, et al. 1994). While one of the teachers demonstrates this perspective, the other teachers did not define their teaching goals by the specific content of their curriculum. Instead, their goals center on helping students gain the knowledge and abilities they will need for their future lives. Thus, for the teachers, the needs and development of their students takes precedence over the specific content of their curricula.

> In the long run, I know students will forget the specifics of what I teach them. What is important is whether or not they leave my class understanding the importance of science to their lives. (Matthew, Interview 1)

The teachers share how they want to develop students' habit of questioning why things are the way they are and their motivation to learn about the science behind their experiences.

> Science is all about, figuring things out. Young kids are so curious, but so many of my students have lost that. I want to help my students to start asking questions again. (Catherine, Interview 1).

Several of the teachers argue that there is no way to know the science related problems that will face our world in the future. Therefore, their students have to develop the interest, self-efficacy and ability to learn more about science throughout their lives.

> You have got to understand science enough to be an educated citizen and you have to be interested enough in it to read about the issues, discuss them and make good voting choices…you have to enjoy and know enough about science to want to learn more. (Diane, Interview 2)

The main goals the teachers describe for their teaching include the development of positive attitudes toward science including that learning science can be fun, that science is relevant to their experiences and useful to their lives; the development of critical thinking skills, particularly the ability to judge the accuracy of information; an understanding of the nature of science knowledge; an awareness of significant science issues that affect life on our planet; and the motivation and ability to continue learning about science throughout their lives. Therefore, when the teachers reflect on their personal teaching goals, they all connect the value of science learning to the understandings and capabilities they feel their students need for their future lives while only one teacher highlight the importance of students learning specific content knowledge.

The teachers goals align with those outlined in the science education reform initiatives. The *NSES* (NRC, 1997) supports that science education must develop students' scientific literacy. Scientific literacy is defined as the scientific understandings and habits of mind that individuals need to become compassionate human beings who can use scientific information to make decisions that face them every day as well as those that will face our nation in the future. As stated above, the *NSES* argues that these goals demand a shift from teachers presenting information and covering science topics to students discovering such information on their own, through inquiry. It emphasize the importance of students negotiating their understandings of science with their teacher and peers, asking questions about the nature of our world, collecting data, accessing information, constructing explanations and communicating their understanding with others. The teachers also support

that providing students with the understandings they will need for their future lives demands that students are actively engaged in their science learning. The teachers want to focus their teaching on supporting students in raising questions, sharing ideas and discussing science content with one another. As I discuss in the following section, however, the teachers face challenges in working towards these goals.

"How come they aren't interested?"

As stated in my introduction, I believe that reform efforts must prioritize the knowledge and experiences of teachers as their understandings will highlight both the obstacles and the avenues to science education reform. Therefore, during my conversations with teachers, we discussed how they feel they are able to implement their reform-based goals and what they see as the main challenges they face. Without exception, the teachers confessed that the most significant challenge they confront is the lack of interest and engagement many of their students demonstrate towards learning science in their classrooms. While the teachers want their students to be active in the learning process, raising questions, sharing ideas and discussing their ideas with one another, they found most of their students were exceptionally passive in their classes. The students' passivity and disengagement are particularly troubling for the teachers since they want to implement more student-centered teaching strategies. All of the teachers shared lessons they believed were exciting and engaging, only to find students less than enthusiastic. The teachers found that many of the methods presented in their education class as ways to motivate and engage students did not engage students as they thought they would.

One teaching strategy that received a great deal of emphasis in the science teaching methods course was the use of discrepant events. A discrepant event is a demonstration of a

phenomena that is surprising in some way. The purpose of using a discrepant is to have students conjure up their current conceptions of the phenomenon, reconsider their understandings and raise alternative hypotheses about what they see. According to the constructivist framework, learning is a means of refining existing knowledge in which conceptual change takes place, rather than the simple gaining of new knowledge (Matthews, 1994; Driver, 1989; Solomon, 1989). From this view of learning, students' prior knowledge, expectations and preconceptions serve as filters for the information that is focused on. From a constructivist viewpoint, science lessons are supposed to involve students in challenging concepts, grappling with them, attempting to make meaning of them, and eventually integrating them with what they already know. Therefore, discrepant events are believed to be an ideal way to engage students' curiosity and get students actively questioning the science behind a particular phenomenon.

David shared an experience he had during his first year of teaching where he utilized a discrepant event to initiate a lesson on the effect of temperature on the molecular motion and pressure of gases. The discrepant event involves placing two balloons in jars, one with very hot water and the other with alcohol and dry ice. In hot water, the balloon expands to fill the entire container while the balloon in the dry ice and alcohol shrinks to a fraction of its size. When David used the discrepant event during a lesson, his students did not respond as he had envisioned. He believed the students would be eager to understand the scientific explanation for the event. He was counting on students sharing ideas, proposing hypotheses and coming up with questions to explore. While his students were excited by the sudden changes of the balloons, they did not show much interest in the science behind the phenomena. The students were silent when he asked for their hypotheses and less than

enthusiastic when he asked them to design experiments to explore hypotheses. David described being confused by the students' lack of interest in pursuing the scientific explanation for the changes in the balloons.

> I was really surprised when they were not into it. When I first saw it, I thought it was the coolest thing in the world. Why are they not interested in why it happened?" (David, Interview 1)

While this is just one example of many stories the teachers shared with me, it captures the nature of the teachers' early experiences in their classrooms. They want their students to be active in the learning process, raising questions, sharing what they already know and discussing the main ideas of the science content with one another. However, they found most of their students silent and passive when it came to exploring the specific scientific concepts that were the focus of their lessons. The teachers shared how, after presenting a question, utilizing a discrepant event or challenging students to perform experiments, the students would often fail to make effort, showing little interest in the topics the teachers were struggling to engage them in. All teachers described being shocked and dismayed by the lack of effort the majority of their students put forth toward their classes.

> The education professors tell you that the kids will be motivated, that they will learn and be happy, that everything will go well if you use the methods they say you should. Then you get in the classroom and the kids resist your best efforts. (Matthew, Interview 2)

The teachers did not experience resistance to their teaching efforts in all of their classes, however. All but two of the teachers taught both honors and academic (lower track) classes. In their honors classes, their students usually gave effort towards the lessons the teachers designed. In their lower track classes, however, the teachers struggle to get their students involved in their lessons. The students in these classes are frequently disengaged during learning activities and often fail to give effort towards class assignments.

Considering the nature of school science

The teachers' experiences with their students in their lower track classes are consistent with research exposing how lower track students often tune out of classroom learning and resist teachers' efforts as a means to cope with the frustration they feel toward schooling they see as lacking value and for maintaining an identity in opposition to school standards of success (Eckert, 1989; Fordham, 1996; Graham, Taylor & Hudley, 1998; Oakes, & Guiton; 1995; Steele, 1997). This body of research also reveals that teachers often attribute lower track students' lack of engagement to factors outside the teachers' control such as a lack of ability, laziness, or a poor home life (Anyon, 1997; Gilbert & Yerrick; 2001; Graham, Taylor & Hudley, 1998; McNeil, 1986). The teachers in my study, however, did not attribute the students' disengagement to a lack of ability or other inherent characteristics. Instead, they associate the students' passive behavior to their lack of interest in learning about science topics they perceive as having little relevance to their lives.

> I still believe that a lot of kids just don't get into the stuff we are expected to teach. They wonder, when in the world am I ever going to use this in my life? (Matthew, Interview 1)

Through their early interactions with their students, they realized that their students do have rich interests in science. They shared how the many of their students who were highly disengaged with classroom activities would often be full of questions about something that happened to someone they knew or something they heard about on the news. The teachers recognize the lack of relevancy many of the topics within their curricula have to their students' lives. The teachers understand that their students see little value in many of the topics included in their curricula and support that this was mostly to blame for their students' lack of engagement.

> The biggest problem I have had is that so many kids are just tuned out. It really makes you try hard to get them to see the relevance of what you are teaching to their lives. Only when they see the relevance will they give effort in class and really learn something. (David, Interview 1)

Instead of blaming their students, they acknowledge the role that the content of the curriculum was playing in their students' lack of engagement. The teachers came to see the curriculum through their students' eyes.

The teachers' comments reveal how the characteristics of their students, particularly their less engaged students, were highly influential in how they have developed their understandings of good science teaching. Initially, the teachers focused nearly exclusively on *how* they taught. The teachers believed they could engage their students if they used the right methods, especially if they used inquiry-based methods that involve students in observing and questioning natural phenomena. Through their early interactions with their students, however, they recognized the importance of *what* they were teaching. They realize that most of their students are not interested in many of the topics within their curricula, regardless of the methods they use to teach them. The teachers discovered, as Hofstein and Yager (1982) contend that curricula focused on learning science for its own sake is motivating to only a small portion of students.

> Most of my students are not just going to learn something because I tell them to, they are going to learn it if they think it is something useful or valuable. It is my job to make sure they feel that way about what I teach. You just have to find a way to reach them. (Catherine, Interview 2)

If we take another look at David's lesson with the expanding and shrinking balloons, we can explore some of the reasons why his students may have been unengaged. While David was trying to involve his students in exploring the phenomenon, his main focus was on teaching a specific curricular objective included in his Standard Course of Study.

Eventually, after the students had a chance to raise (or not raise) hypotheses he was going to tell them the laws and theories that explain the relationship between the temperature and the kinetic motion of the gas molecules as well as how this impacts the pressure of gas and the volume it takes up in the balloon. The students were asked to write down this information in their notebooks so they could reproduce it later on a test. The activity is typical of school lessons where actions are made in the pursuit towards one right answer that the teachers knows and the students will be expected to know (Heath, 1983; Mehan, 1979). Also typical of high school science, the lesson asked students to learn about the behavior of molecules and atoms, objects beyond their scale of experience. Therefore, successfully learning the material involves the individual endeavor of manipulating symbolic knowledge that is abstracted from everyday life (Fusco, 2001).

While understanding the interaction of temperature, pressure and volume of a gas is essential to understanding the phenomena of weather, especially the formation of storm systems, the students did not connect this school science episode to their experiences seeing summer thunderhead clouds. David's curriculum did not include an objective that students will understand how a thunderstorm develops. Instead, his curriculum includes a list of scientific concepts deemed as most important within the discipline of earth science. As is currently the case in high school science, the subject matter takes precedence over that of its application and connection to everyday life. Science is presented as a body of facts and theories existing "out there" (Cobern, 1996). The result is often a fact-oriented science which appears decontextualized, objective, rational and mechanistic (Brickhouse, 1994). The laws and theories are prioritized and students are expected to learn the scientific subject matter for its own sake.

It is the lack of connection of school science to students' out of school, everyday experience that many educators argue results in the marginalization of students from science. Numerous educators criticize how little school science intersects with the lives of students (Barton, 1998; Cole, 1998; Lee, 1999; Rodriguez, 1998; Seiler, 2000). These educators argue that the science knowledge currently prioritized in schools, particularly in high schools, is based on white, middle class experiences, desires and goals while the needs of many students, particularly urban students and students of color, are being excluded. Barton (2001) discusses how the narrowly defined science within schools is so separate from the context of personal experience that students do not see how the skills and knowledge they acquire in school have currency outside of school. Therefore, students fail to see school science as relevant to their goals. Many educators insist that if science is to be relevant to all learners, it must respond to and emerge from the life experiences, questions and interests of all learners (Atwater, 1996; Barton, 1998; Dewey,1916, 1938; McBane & Yager, 1996; Rodriguez, 1998). Barton (1987) argues for a "decentering" of school science where classrooms integrate and make use of students' lived experiences as the means to teach science.

Through their first two years of teaching the teachers realized, that the "urgency" and "vitality" that drive our spontaneous desire to know are lost when knowledge is presented in abstract often highly symbolic ways (Dewey, 1916, p. 8). The teachers also discovered that their students, "are interested in the world of things mainly in its connection with people as a background and medium of human concern (Dewey, 1902, p. 48). To maximize student interest and effort, the teachers have minimized the focus on the more abstract, factual information of the curriculum while emphasizing those topics with clearer connections to real life events. Thus, the teachers have shifted the focus of their classroom from the specific

facts and terms outlined in their textbooks to how these topics connect to students' lives and interests. They found their students were quite interested in learning about the science related to real world events; to the science they see on TV and in movies; to experiences they have with their own bodies and especially with current controversial and ethical issues related to science within the media. Therefore, they strive to find ways to "reframe" the content of their curricula, constructing their curriculum in ways that link the content to their students' lives (Barton, 1998; Fusco, 2001; Seiler, 2000).

In the following section I share how the teachers' ideas about how students learn and what they should learn were implemented through specific lessons and inquiries. These classroom incidents demonstrate how the teachers focus their students' explorations of their curricula on real-life events and issues, "decentering" (Barton, 1998) school science in ways that include more of students' lived worlds. As I share the teachers' lessons, I connect their strategies to the ideas of Dewey (1916, 1916, 1938) as his writings offer insight into the dilemma the teachers face between balancing the needs of the student with the demands of the curriculum. I have also chosen to highlight Dewey's educational ideas because I was struck by how the teachers' lessons align with his focus on problem based learning and how their arguments for greater authenticity in learning echo his. I include discussions of the teachers' lessons as they demonstrate how the teachers are successful in expanding the typical borders of high school science as well as provide models of reform based teaching relevant to typical public high school science classrooms

It is essential to understand, however, that the teachers' ability to reframe their curricula in ways that focus on and incorporate students' lived experience depends on their perceived level of curricular freedom. All of the teachers in the study taught biology while

five of the teachers also taught earth science or a science elective. I make the distinction between the biology and earth science or elective classes because high school biology is currently subject to an end of course exam (EOC) while earth science and science electives are not. As I explore in the following chapter, the pressure teachers are under to prepare students for high stakes tests prompts them to focus their classroom instruction on the specific factual information that students will be tested at the exclusion of how the information relates to students' lived experience. Therefore, the following discussion, which reveals how teachers successfully connect the content of their curricula to students' lives is powerful because it also exposes all that is lost when this connection is severed by the pressure to teach to a test.

Reframing school science

One of the ways teachers found to connect the content of their curricula to the lives and concerns of their students was to take advantage of current events. As critical science educators do, Dewey (1916) argued that the connections students build between their out of school life and their in school life determine their interests in the curriculum. All of the teachers have found that inquiry into real life events results in the most engagement from students. The teachers support that these interactions develop positive attitudes towards science where students can experience the satisfaction of understanding their world on a deeper level.

In her earth science class, Lucy responded to the high level of student interest surrounding a strong hurricane that was headed toward the North Carolina coast.

> Back during hurricane season, we had a great time. I wasn't even teaching weather but when the hurricane formed and was expected to head our way, the students were really interested. So we hooked up the national weather center website and the students had to figure out where it was headed based on the weather systems at that time. We kept a

> hurricane tracking chart and we had wonderful discussions. I was able to do our mapping unit and most of the weather unit then. (Lucy, Interview 1)

In this lesson, Lucy capitalized on a real life event that was directly relevant to students' lives. Thus, the focus of her class emerged out of the experiences of her students. Lucy's lesson aligns with Dewey's (1916) notion of teaching "indirectly". Many of Dewey's writings on education focus on how teachers can support the excitement, self satisfaction, and fulfillment that come with discovery and learning. As discussed earlier, one of the teachers' main goals is to get their students excited about science and help them experience the feelings of satisfaction from understanding their experiences on a scientific level. Dewey (1916) argued that, "one of the weightiest problems with which the philosophy of education has to cope is the method of keeping a proper balance between the informal and formal, the incidental and intentional, modes of education" (p.9). While Dewey did not support forms of teaching where students are able to learn at their whim, he strongly criticized viewing students as empty receptacles in which to pour the factual wisdom accumulated of the various disciplines. He remedies these two extremes by supporting that the vitality of informal learning can be maintained in a formal school setting by teaching indirectly. Dewey insisted that teachers should work with students to find genuine problems that can be solved through engagement with the topics of the curriculum as Lucy did by taking advantage of an approaching hurricane.

Dewey (1916) argued that focusing learning on real life problems prompts students to need the content of the curriculum and, as a consequence, they are prompted to explore it, use it and remember it. By challenging her class to make predictions on where the hurricane was headed, Lucy's students needed to understand how the current atmospheric conditions, such as air pressure and air temperature would affect the hurricane's path. In addition, they

had to become familiar with how the earth is divided into latitude and longitude coordinates to identify the hurricanes exact position. Thus, the students needed the content of the curriculum to solve the real life problem of tracking the impending hurricane.

Some of the scientific understandings the students gained through their inquiry into the hurricane align with the concepts David was trying to teach with his expanding and shrinking discrepant event lesson. However, instead of focusing on a decontextualized scientific law, Lucy's class focused on a real life event that had the potential to impact their community, which was likely a focus of conversation in their homes. Several of the teachers shared instances of how they engage their students in inquiries into real life events such as tsunamis, volcanoes and mudslides and how interested and involved their students were. According to Dewey (1938), the litmus test for education is the impact students' experiences inside of school have on their experiences outside of school. Lucy commented that she hopes her students will never look at a hurricane forecast the same again since they would understand how the meteorologists were making their predictions and the factors they were using to predict the hurricane's path.

All of the teachers discovered the importance of increasing the authenticity of explorations in their classrooms in order to elicit more student input. Matthew shared how he was displeased with the lack of engagement his students dedicated toward identifying the rocks available in the curriculum kit his department has always used to teach lessons on identifying rocks and minerals. In the previous semester he decided to take his class to a rock outcropping on the school campus instead of using the curriculum kit. There, the students engaged in the same series of tests to identify the rocks as they would have with the kit. He commented that he was surprised when several students picked up various rocks

around the site and questioned what type of rock they were. The critical difference between the students identifying the rocks in the curricular kit and those on their school campus is the authenticity of the exploration. Instead of a contrived lesson where there are predetermined answers, the students' innate curiosities were tapped as they worked to develop a deeper understanding of the rocks they see everyday rather than a set of rocks kept in a supply cabinet. Dewey (1916) supported that science classrooms should focus on the common stuff of everyday experience where students could turn their everyday experiences into scientific understandings.

Critically questioning scientific information

In addition to focusing classroom actions on inquiries into real life events and observations, the teachers also utilize science stories in the media to engage their students in science inquiries. In her biology elective class (non-tested class), Sarah shared how she frequently changes her classroom focus to the latest biology related news stories. When a large oil spill occurred off the coast of Alaska, her class stopped what they had been doing and used data about the surrounding area to predict the impact the spill would have on the local wildlife. One of the students came upon an article on Exxon's website claiming that the region of the famous Exxon Valdez spill has returned to its original state, using data on sea bird populations to back their claim. Sarah capitalized on this opportunity and challenged the students to assess the validity of Exxon's claim using data available from the department of wildlife website. Through this inquiry, her students learned about the existence of indicator organisms that denote the health of an ecosystem and the long term impact of pollution on the biodiversity of wildlife. In addition to the knowledge they gained related to biology, they gained skills in assessing the legitimacy of scientific arguments and an understanding of the

importance of a variety of data sources. They also learned that statistics can be used selectively to misrepresent reality.

In the previous year, her class changed its focus to cloning when the Clonaid human cloning scandal hit the press. The class did some research and debated whether or not the human cloning claim could be authentic as well as whether or not legislation should be made to limit research on human cloning. Sarah shared how her students are very interested in information related to controversial matters. One strategy she has found successful is capitalizing on the drama of particular stories is having students write news stories, editorials or even tape a news program for a project. Here, through these teachable moments, Sarah provides her students with practice in critically analyzing information presented as "scientific." Educational theorists point out that the capacity to question and reflect critically on issues, which Gutman (1987) describes as the *democratic virtue,* is crucial to participation in a democracy (Dewey, 1916, Freire, 1970; Shor, 1992). Hofstein and Yager (1982) support that making curricular decisions on the basis of relationships to current, real-life societal problems, issues and concerns to give school science more cultural validity. Eisenhart, et al. (1996) insists that such a focus within science classrooms will allow students to see science as something that is important to their lives and their community outside of school. .

Films and curricular connections

Since there are many aspects of their course curricula that are not related to current phenomena or events, the teachers had to develop creative strategies for connecting curricular topics to students' experiences and interests. One method teachers use to make these connections is through films. Films allow their students to see the human stories related to science, to observe science phenomena and see how this phenomena impacts

human life. While films dedicated to science education are infamous for being sleep inducing for students, the teachers use Hollywood films to make curricular connections more exciting and relevant to students' personal lives, utilizing an avenue of relevance through pop culture. The teachers found viewing segments of a film a strategic way to have students "experience" a particular phenomenon or learn about the human side of a science topic. Even though the scientific phenomena in films are the product of special effects, the teachers have discovered that an analysis of the accuracy of these depictions can build a bridge between student experience and science. The teachers found that seeing the science phenomena on screen was successful in getting students thinking and talking about the topic.

David uses several films in his earth science class to help students understand the nature of science and how our scientific understandings change over time. He has students watch *Journey to the Center of the Earth* (Levin, 1959) and challenges them to find the various incorrect scientific representations within the film. He insists that finding the scientific misconceptions allows students to feel competent in science and prompts them to raise questions about the scientific representations. After discussing the science in the film, he divides students into groups and each group researches a specific scene or scientific portrayal to learn more about the current understanding as well and the class discusses how more recent research negates the representations portrayed in the film. In addition, his class watches an old Cousteau documentary and then a new one to talk about how the deep sea exploration vessels, Alvin and Jason, have permitted discoveries scientists about deep sea life. Both of these activities emphasize the nature of science, the human stories behind science and the essential role technology plays in developing our scientific knowledge.

Matthew uses segments of *Jurassic Park* (Spielberg, 1994) during his unit on dinosaurs to emphasize the controversial nature of science knowledge. He asks the class to observe the ways the film depicts the different dinosaurs' behaviors such as how they move, whether they hunt alone or in groups and whether or not they are carnivores or herbivores. The class then assesses the evidence available for the different dinosaur species depicted in the film and reads an article from a scientist challenging the way one of the species of dinosaurs is portrayed. After this research, the students debate whether or not they feel the film depicts the dinosaurs accurately. The film permits students to see and experience depictions of the dinosaurs fostering more interest in inquiring into these organisms than a flat picture in a textbook.

The benefits of the explorations discussed above are that the students gain more than just an understanding of specific science content; they also gain an understanding of the nature of science. Through their interrogations of the films, the students gain the understanding that science claims are often based on a limited amount of data, that scientific depictions and theories are up for debate, that science changes over time and the collective efforts of many scientists progress our understanding of the world. The teachers' lessons, particularly Diane's Clonaid and oil spill inquiries as well as Matthew's inquiry into the representations of dinosaurs in *Jurassic Park* (Spielberg, 1994) align with many of problem posing strategies supported by a wide range of critical and democratic educators (Dewey, 1916, 1938; Freire, 1970; McLaren, 1989; Shor, 1992).

Instruction that encourages careful examination of the material, considering multiple perspectives and the historical context of information are core components of critical pedagogy (Shor, 1992). The teachers in this study utilize problem posing to raise awareness

about some of the controversies surrounding the science topics and engage students in thinking critically about knowledge that is presented as fact. In these lessons, students are challenged to assess the situation themselves rather than having objective factual information delivered to them through a lecture. The students are challenged to explore the issue and, after doing so, formulate their own opinions in cooperation with others. In Chapter 6, I connect the strategies teachers utilize in their non-tested classes to the development of students' democratic capabilities. While there are accounts within the literature of high school teachers engaging students in inquiry into real life events, there is little discussion of how teachers support citizenship education within their science courses (Crawford, 1999, 2000; Fusco, 2001; Roth, 1995; Seiler, 2000).

These lessons counteract the traditional portrayal of school science as a body of knowledge that consists of events, facts and theories existing "out there" (Cobern, 1996) by emphasizing the dynamic nature of science instead of the static vision most often presented within science classrooms (Yager, 1990). Thus, students gain an understanding that science is not a separate, objective or irrefutable body of truth, that there are controversies and ongoing discussions about the representations we have made of our world. Instead of the people and tools responsible for the understandings being hidden, they are explored and discussed (Roseman, et al, 2001). Furthermore, the students gain an understanding of how human feelings, such as wanting your dinosaur to be a fearsome pack predator instead of a solitary herbivore, also play a role in the production of scientific understandings. Therefore, scientific ways of knowing are not based solely on rational thought separated from emotion (Brickhouse, 1994).

Discrepancies in reform-based teaching

In the previous discussion, I focus on the teachers' favorite lessons and moments where they feel they have been successful in implementing some of the goals of science education reform. I also share these examples because they show how the teachers are successfully able to break away from the traditional conceptions of school science. I support that a focus on teachers' successes captures more of who they are as a teacher than a critique of aspects of their practice that do not measure up to outside standards. Given the challenges the teachers face on a daily basis and the conditions under which they work, the efforts they put forth to make connections with their students should be celebrated. However, I do not want to represent the teachers in ways that are not accurate. While I focus on the lessons teachers are most proud of in this chapter, they admit that their students are not always actively engaged in their classrooms. They confess that they resort to more teacher-centered, student passive pedagogies when they are teaching topics that lack a direct connection to students' lives and when they can not think of or have not had the time to think of more authentic ways to engage students. Some particular topics in earth science the teachers confess to teaching in a teacher-centered way include the layers of the earth, erosion patterns, geologic time, rocks and minerals and the rock cycle.

While their teaching at times involves them standing in front of the class lecturing to students, they insist that they continue to prioritize a focus on how the subject matter intersects with human life. Several of the teachers share how they teach topics with lower interest quickly in a more information transmission style so they have more time for the topics students find more interesting. These teachers feel if they address the content, even minimally, they meet their curricular expectations. One teacher even shared how she tells

her students that if they will just "hang in there" while she goes over rocks and minerals, they will spend more time on weather. The teachers confess to utilizing teacher-centered strategies off and on throughout their semester. Therefore, the teachers use a range of strategies, some of which they are more proud of than others. This highlights how research that attempts to categorize teachers into specific categories or assign teachers a reform rating via a single classroom observation without extended conversations with teachers will not permit an understanding of the nature of a teacher's practice or teaching goals (Gitlin, 1990; Keys & Bryan, 2001).

The teachers do acknowledge that many of their inquiry activities are more teacher-centered than the *NSES* (NRC, 1996) recommends. They admit their obligation to teach their curriculum prevents them from capitalizing on student interests and questions on a regular basis. Kohl (1969) argues that the "teacher has been hired to teach a specific subject and, because of that fact, is restricted in her own freedom" (p. 43 cited from Shor, 1992). Even though their earth science classes are not subject to an EOC, the teachers continue to feel an obligation to focus on most of the topics in their curriculum, regardless of whether or not they feel they have value for their students. The teachers shared that many of their teaching actions are motivated by their interest in being a positive influence on their students' lives. Teaching is also their job and they are aware that they are hired to teach the mandated state curricula. While an educational researcher, such as myself would celebrate their decision to cater their classroom completely to student interests, their fellow teachers and administrators are not likely to be impressed.

During his first year teaching, Matthew was told that all of the earth science teachers in his department give a common midterm and final exam. Being a new teacher, Matthew

did not feel comfortable being the only teacher to give a different exam and, therefore, diligently taught every topic in the mandated curriculum. During his second and third year, however, he altered the test to align more with what he taught. He commented, however, that the rest of the teachers in the department did not know that he altered the test. When I asked him why he did not feel comfortable breaking away from this tradition and giving his own exam, he shrugged his shoulders and replied, "Why rock the boat when you don't have to?"

Matthew's comment reveals that he is aware that aspects of his teaching go against the status quo in his department and is slightly anxious about how the veteran teachers might respond. Therefore, as Matthew attempts to adapt his teaching in ways he supports are best for his students, he bumps up against the prevailing practices of school science. His story is an example of the control schools are able to exert over teachers' actions. Furthermore, the teachers' sense of obligation to teach the mandated curriculum highlights their subordinate status to the policies that direct their schools. The extent to which schools are currently controlling teacher actions and the ways in which they gain such control is explored in detail in the following chapter.

Chapter Summary

As stated in my methodology chapter, the six teachers who participated in this study left their teacher education program passionately voicing their intentions to teach in a reform-based manner. My study reveals that these beginning teachers have been successful in implementing many of the ideals of science education reform in their high school science classrooms. The teachers' have maintained many of the beliefs they held when they left their teacher education program. Thus, my findings challenge the common conception within the literature that beginning teachers fail to implement the reform-based ideas about teaching

once they enter their own classrooms (Benson, 1999; Carlsen, 1991; McDairmid, 1990; Pajares, 1992; Rusk, 1994; Wideen, et al., 1998; Zeichner and Tabichnick, 1985).

The teachers' beliefs about teaching were challenged during their early teaching experiences as students' lack of engagement and lack of effort towards constructivist based lessons threatened the teachers' ability to actively involve students. However these challenges did not force the teachers to revert back to deeper beliefs about the teaching and learning that they acquired during their "apprenticeship" under traditional teachers (Lortie, 1975, Richardson, 1996; Pajares, 1992). My study reveals how the teachers continue to hold their student-centered beliefs and have even refined them in ways that are likely to bring them closer to engaging a wider range of their students.

The way in which the teachers in this study interpret their students' lack of effort and engagement is distinctive within the literature. They do not attribute it to factors outside their control such as lack of ability, laziness, or a poor home life as previous research has found (Anyon, 1997; Gilbert & Yerrick; 2001; Graham, Taylor & Hudley, 1998; McNeil, 1986). Instead, through their early interactions with their students they have come to understand that their students are interested in learning about the science related to their lives while science knowledge for the sake of science holds little value (Dewey, 1916, 1938; Barton, 1998; Hofstein & Yager, 1982). The teachers understand how their students' interests and desires connect to the content of their curricula. While researchers point to the need for novices to develop an integrated understanding of pedagogical content knowledge that allows them to transform subject matter into an understandable form, these novice teachers are also able to transform the subject matter into a form that is more interesting and engaging to their students (Grossman, 1991; Shulman, 1986). The teachers' pedagogical content knowledge

includes an understanding of both the importance of and means to adapt their subject matter in ways that connect it to students' out-of-classroom lives.

Research on teaching within lower track classroom exposes how many teachers react to students' lower engagement by focusing on lower level thinking and rote memorization instead of higher order, critical thinking tasks (Anyon, 1997; Gilbert & Yerrick; 2001; Graham, Taylor & Hudley, 1998; McNeil, 1986). The teachers in this study, however, actually reduce the lower level thinking and memorization tasks by minimizing the more abstract knowledge and terminology of the curriculum and highlighting the interpretive aspects. The ways in which they reframe the focus of their curricula align with many of the recommendations for supporting the learning of students who are traditionally excluded from school science (Atwater, 1996; Barton, 1998; Brickhouse, 1994; Cobern, 1996; Cole, 1998; Hofstein and Yager, Eisenhart, 1996; 1982; Lee, 1999; Rodriguez, 1998; Seiler, 2000). The way the teachers emphasize the human research narratives behind the content of the curriculum and the tentative nature of science knowledge is particularly striking. Science teachers, especially at the secondary level, often portray science as an objective body of knowledge (Cobern, 1996; Gallagher, 1991, Tobin, 1994, Yager, 1990). The teachers in this study, however, strive to orient students to the tentative, contextual nature of science knowledge.

While teacher induction literature usually presents teachers' beliefs as static and resistant to change, my study offers support for feminist articulations of teaching where beliefs are understood to constantly evolve. Research on teacher thinking indicates that teachers are active curriculum creators who make instructional decisions on a complex system of beliefs and knowledge (Bryan & Abell, 1999; Clandinin & Connelly, 1992). My

conversations with teachers reveal how their beliefs and practices have evolved over their first three years of their teaching. When challenged by low levels of student involvement, they reassessed and reformed their thinking. I believe that my close relationship with the teachers, our extended conversations and my prioritization of their understandings of their practice allowed me to see such changes that other research may overlook.

CHAPTER FIVE

SEPARATION OF THE STUDENT AND THE CURRICULUM

In the previous chapter, I discussed several examples of how the teachers engage their students in explorations of real live events and issues, shifting the focus of learning from the specific facts contained in their curricula to the ways in which the topics connect to students' lived experience. Thus, instead of teaching science for the sake of science, they were teaching science for the sake of helping students understand real life events and issues. In this chapter, I explain how high stakes tests discourage teachers from focusing their instruction on real life issues (McNeil, 2000). Instead, the pressure to prepare students for the tests encourages teachers to focus on the basic factual information related to the subject matter (Calder, 1990; Madaus, 1991; McNeill, 2000; Rottenberg & Smith, 1990; Shepard, 2000; Wideen, 1997). It is essential to understand that the teachers I speak of in the tested and non-tested classes are the same teachers. All but one of the teachers in the study teaches both tested (biology) and non-tested (earth science and science electives) classes. Therefore, my study reveals that the teachers teach their non-tested classes in a significantly different way than their tested classes due to the demands of the high stakes test. The presence of the test persuades teachers to teach in ways that are opposed to their beliefs (McNeill, 2000).

While I expected that testing would limit teachers' curricular freedom, I never expected the extent to which it would remove students' experiences and interests from the focus of learning. In this chapter, I explain both how the test has impacted the teachers practice as well as why it has had the significant impact my study reveals. I will share the

details of how the teachers experience the pressure of testing and how this prompts them to design their practice around what they believe will raise student scores rather than what they believe is best for student learning. By focusing on how one teacher chooses to teach a unit on genetics, I explore the various ways the phenomena of high stakes testing encourages him to focus on the specific factual details instead of the connections between the molecular genetics and his students' lives. My study exposes how a multitude of factors are involved in the teachers' decisions to focus their instruction on preparing students for the test (McNeill, 2000; Webb, 1999).

In the following section, I explore the various ways the accountability policies impact the classroom actions of teachers. As I revealed above, I was shocked when the teachers revealed they feel no choice but to utilize teacher-centered, information transmission strategies. I did not understand how a test could cause the teachers to go against their beliefs and teach in ways they acknowledge are harmful to their students' learning and attitudes toward science. As I listened to their stories, however, I came to see the variety of ways the accountability policies manipulate their classroom actions.

The stakes involved in high stakes testing

North Carolina has been testing students on their knowledge of the state mandated curricula in required courses since 1992. In the 1990's, these statewide exams were used to ascertain what percentage of students had attained knowledge of the standard course of study and were originally implemented to help schools identify schools that needed additional assistance. Over time, however, the tests have been used for different purposes. Testing has moved from a broader measure of student learning to an individual system of ranking and comparing students as well as a mechanism for public comparison of teachers, schools and

school systems (Cimbricz, 2002). As part of the No Child Left Behind (NCLB) (2001) legislation, student test scores are connected to a system of rewards and penalties.

Currently, high schools are assessed by the percentage of students who demonstrate proficiency on the standardized End Of Course Exams (EOC). Under NCLB (2001), schools are assessed by the percentage of students who meet proficiency standards as well as how this proficiency percentage increases each year. Each year, the state establishes an adequate yearly progress goal establishing how the school's scores must improve over the year. Therefore, the goal schools are trying to meet increases every year. The teachers learned early that their schools are under extreme pressure to meet the adequate yearly progress goal and this pressure is passed on to the classroom teachers. For all of the teachers, the initial school faculty meeting focused solely on the school's previous EOC scores and how the scores need to improve. For one school, all four professional development seminars focused exclusively on how to develop students' testing skills.

Again, NCLB (2001) connects rewards and penalties to yearly progress goals. Currently, teachers receive a monetary reward of $750 if the students in their school meet the progress goals set by the state and $1500 if the students' scores exceed the goals. If the schools do not make expected growth for 3 years, the school is taken over by a state assistance team. School administrators also have high stakes involved as they earn significant bonuses if their schools make exemplary growth as well. If their school does not perform well, however, they are likely to lose their jobs. While the incentives and punishments are earned and received by an entire school, student scores are divided and reported by individual teachers. Therefore, teachers and administrators receive reports that indicate how a teachers' students performed on the test permitting different teachers to be

compared to one another. The teachers argue that they feel their teaching is evaluated exclusively by their students' scores. The anxiety they experience from this scrutiny encourages them to focus their teaching on preparing students for the test even though these efforts conflict with what they feel is best for their students

The scrutiny of test scores

To highlight the pressure teachers are under, I am going to share Catherine's story as it reveals the extreme pressure both teachers and administrators are under to improve student scores. Because Catherine's school had not obtained the growth goals set by the state for the previous two years, the school was in danger of being taken over by a state assistance team. The previous principal had been fired and a new principal arrived to "whip the school into shape". The extent to which the administrator separated and singled out teachers in an effort to control their actions in their classrooms is startling.

> When the new principal came, we had our faculty meeting at the beginning of the year and she said, 'All I care about is EOC scores. I am going to be talking to you about your EOC scores from last year and we are going to talk about how you are going to fix them.' (Catherine, Interview 1)

The administrator met with each teacher individually and they were expected to present their strategies for increasing their students' scores. When I asked Catherine what sort of things the administrator did to help the teachers move toward the school's progress goal, she described acts of intimidation.

> By yelling at us, by using fear. She would make threats. She would tell us that she was going to be around, that she was going to be checking all of our teaching. 'I am going to be walking in your door anytime to make sure you are on task and make sure you are teaching the mandated curriculum.' She wanted to make sure we were not talking about anything except the topics emphasized on the EOC. (Catherine, Interview 1)

When the semester was over the teachers were singled out again as they the went to the administrator's office to retrieve their students' scores. While Catherine's honors class

received a 100% passing rate, her inclusion class did not do as well as the administrator wanted.

> She said that the scores needed to be better and asked me what I was going to do differently the next semester. I came out of her office and started crying. She never directly threatened my job, but it always seemed like it because she would yell at me and I didn't feel appreciated. (Catherine, Interview 1)

While the administrator did not directly threaten the teachers' jobs, she did threaten to take away their preferred classes. The administrator told the staff that she was going to use the EOC scores to figure out which teachers were best to teach the EOC courses and which ones would be assigned to non-tested courses. Catherine talked about how awful it was not to know what she would be teaching that next year. "I feared all summer that I would walk in and not be teaching biology because I love biology. I don't want to teach earth or physical science." (Catherine, Interview 1)

While Catherine's experience was the extreme, it was not the exception. It reveals the tremendous pressure administrators are under to meet the mandated goals and thus, the pressure that is passed onto teachers. All of the teachers are subject to unannounced observations by administrators. All of the teachers are expected to have the specific standard course of study objective being taught on the board at all times to facilitate an analysis of their teaching. The teachers argue that the purpose of the observations is not to see if they are teaching well, but to see if they are teaching the specific curricular objectives in an efficient manner. One of the teachers is expected to submit her lesson plans to her administrator at the beginning of each week.

The teachers' administrators are not the only individuals involved in the scrutiny of their students' scores. In one school, the student passing rate for each of teachers is posted in the staff lounge listed in order of highest to lowest. In two of the teachers' schools, the

passing rates for each of the teachers is posted on the school website. While they do not want to teach to the test, their fears of being seen as a teacher with lower scores is one of many factors that persuade the teachers to plan their instruction around the test. Furthermore, school test scores are published each year within local newspapers. The teachers do not place much value on student test scores. They are impacted, however, by knowing that they and their schools are being evaluated by them. The teachers confessed that this scrutiny is powerful in how it prompts them to focus their teaching on preparing students for the test.

It is through surveilance and scrutiny, Foucault (1975) argued, that modern society exercises its controlling systems of power and knowledge. The teachers' schools bear striking resemblance to Jeremy Bentham's "Panopticon" design for prisons, which Foucault compares to the modern disciplinary institutions in *Discipline and Punish* (1975). In the Panopticon, a single guard can watch over many prisoners while the guard remains unseen. Foucault compares the strategy utilized in the Panopticon to modern institutions that exert their discipline not through force, but through careful observation, and molding of the bodies (teachers) into the correct form (strict adherence to the tested curriculum) through this observation. The power yielded by this form of discipline is gained through the constant possibility of observation. The teachers are aware that they are under surveilance and that their students scores are being used to assess whether or not they are adhering to the acceptable teaching behaviors. Although they do not see high test scores as valuable, the teachers realize they work within a system that uses the tests to define academic success for the students as well as professional success for them and their administrators.

While the teachers feel pressure to prepare students for the EOC for the sake of their professional and public standing, they are also obligated to focus their instruction on test

preparation for the sake of their students. North Carolina accountability legislation mandates that a minimum of 25% of a students course grade be determined by their EOC score. In two of the teachers' schools, however, the portion of students final grade determined by their EOC score has been increased to 30%. The teachers shared that this stake was the most significant in their decisions to alter their teaching in ways they believed would help students achieve high test scores (McNeil, 2000). The linking of the test scores to the students' permanent academic record makes noncompliance very serious. Therefore, the accountability policies have hijacked teachers' care for their students. Even though they believe teaching to the test is harmful for their students science learning, not teaching to the test could jeopardize their students achievement standing. In the past year, several school boards approved policies requiring high school students to pass the EOC in order to receive credit for the course. If more school boards follow suit in the upcoming years, the pressure teachers are under to teach to the test will only increase as, for many students, their high school career will depend on their EOC performance.

Testing and curricular shifts

My conversations with high school science teachers exposed the reality of what happens to science instruction and science learning when a paper and pencil test determines the knowledge of value. The pressure teachers are under to prepare students for the EOC has encouraged them to shift their focus from students' experiences to the specific factual information prioritized on the EOC. The impact of this shift on how the teachers and their students interact with the curriculum is tremendous. Below, I use two of the teachers' comments to demonstrate how high stakes testing has impacted the style of teaching and learning in the teachers' classrooms. On the left is Lucy's quote about her earth science

inquiry into the science behind an approaching hurricane. On the right is a quote from David about his biology class, which is subject to a mandated EOC. While Lucy's class focuses on inquiry into a real life event, David's class focuses on the specific factual information likely to be asked about on EOC test questions.

"Back during hurricane season, we had a great time. I wasn't even teaching weather but when a big hurricane formed and was headed our way, the students were really interested. So we hooked up the national weather center website and the students had to figure our where it was headed based on the weather systems at that time. We kept a hurricane tracking chart and we had wonderful discussions. I was able to do our mapping unit and most of the weather unit then." (Lucy, Interview 1).	"I am very behind this year. There are only two weeks left and I haven't done plants and animals yet. I actually did genetics in one full swoop. The test always asks questions about the structure of DNA and the specific enzymes so I am focused mostly on that. It is very complicated, but I try to present it piece by piece…I try to give them as much information as I can. I figure, maybe if they have the information, they could figure out or at least recognize the answer." (David, Interview 1).

As discussed in Chapter 4, Lucy's students learn the subject matter of the curriculum as they use it to solve a real life problem (Dewey, 1916; Krajick, 2000). Therefore, their knowledge of weather related concepts and mapping techniques will be connected to the problems these understandings help solve. Lucy's use of the word "we" throughout her description highlights the collaborative nature of the students' learning and the focus on sharing and discussing. Furthermore, she emphasizes students' positive attitudes and emotions as they are challenged to understand an event they see multiple times every year. Lucy's hurricane inquiry represents the ideal the teachers worked toward in their non-tested courses. Unfortunately, the teachers do not feel free to work toward this ideal when their class is subject to an EOC. It is clear from David's comment that the presence of the EOC encourages him to utilize a banking model of learning (Freire, 1970) rather than the more authentic, inquiry-based approach he utilizes in his non-tested classes.

The incompatibility of inquiry and testing

In the following discussion I examine the factors that encourage teachers like David to teach in a manner that goes against their beliefs. To explain the various factors, I first present how David could teach the curricular content in a manner that is aligned with his preferred pedagogies (i.e. teaching the content through inquiries into real life issues). I then explore the various reasons why David feels he cannot teach in this way and properly prepare his students for the test. I have organized my exploration in this way because I know that educators often read descriptions of classroom practice and imagine how they would do it differently.

Because most creators and consumers of educational researchers are educators, descriptions of teaching are viewed with an insider lens and the challenges presented in research are subconsciously solved. I know this from personal experience. Before I conducted this study, I dismissed the teachers' arguments that high stakes testing prevents them from utilizing students centered pedagogies. My dismissal of their arguments came in part from my own assumption that I would never let a test prevent me from doing what I believe is best for my students. I also believed that student-centered teaching would support deeper understanding and, therefore, result in higher test scores. Since I believed I had a better solution to testing, I did not give the teachers' view legitimacy. As Kincheloe (1997) stated, "Any representation of the world manifests its power through its foreclosure of worlds not represented."(p. 67). The strength of my belief came at the disregard of the reality the teachers face. Only through extended conversations with the teachers did I come to understand the reality of how the EOC determines which aspects of science should be

prioritized in the teachers' classrooms and the impact this curricular control has on the teachers' classroom practice.

In their non-tested classes, the teachers identify a real life issue and focus classroom actions on inquiries into the issue, allowing the students to learn about the content while also understanding its relevance to their lived experience. Looking at the North Carolina Biology Standard Course of Study (NCDPI, 1999), we would find that David was teaching objective 3.01, "Analyze the molecular basis of heredity including: DNA replication, protein synthesis and gene regulation" (p.4). Students could gain an understanding of DNA replication, protein synthesis and gene regulation by pursuing the question, "What is the harm in a little sun bathing?" Inquiring into this question would allow students to learn about the molecular and cellular nature of cancer. They could explore how the cell closely regulates the synthesis of growth factor proteins through tight gene regulation and how the sun can damage and mutate these genes leading to excessive cell division and tumor formation. This inquiry would allow the students to learn about the genetics content while also supporting David's other goals, such as developing positive attitudes about the value of science, students' ability to work collaboratively to solve problems and students' ability to make personal health decisions based on their scientific understandings. So why has David chosen to use a banking model (Freire, 1970) of teaching instead of an inquiry-based exploration such as this? The answer reveals how the practice of measuring success by a test has resulted in school science being determined by what is tested and testable (Calder, 1990; Madaus, 1991; McNeill, 2000; Rottenberg & Smith, 1990; Shepard, 2000; Wideen, 1997).

In the following section I discuss how the large amount of content students are required to know for the test, the abstract nature of this content and the type of

understandings demanded by test questions encourage teachers to choose teacher-centered strategies over the student-centered ones they utilize in their non-tested classes. The teachers confess that the tests have become more their goal of instruction, rather than the means to assess it (Brown, 1992, 1993; McNeill, 2000; Smith, 1991).

> I think if you were to ask anyone who has an EOC, it is the biggest player in what gets taught, how in depth stuff gets taught and what doesn't get taught. You are solely trying to fire away, fire away, fire away to the test. (Diane, Interview 1)

As discussed before, the teachers are aware that their professional standing and their school's standing depend on student scores. The factor that causes teachers the most anxiety about the test, however, is the connection of students' credit for a course to their performance on the EOC (McNeill, 2000). This places teachers in an ethical dilemma between teaching students the content they see as most valuable and teaching the content they feel will prepare students for the test. All of the teachers expressed anxiety over the possibility that they will not be able to teach everything the students will be tested on. They feel it would be unfair for their students to see questions on topics that were not covered in class. Therefore, the teachers' concern for their students' welfare prompts them to prepare students for the test even though in the act of doing this they teach in ways they believe are harmful for their students.

Teachers' anxiety over covering all the information students might see on the test causes the mandated curriculum to assume a more significant role in their practice than it does in their non-tested classes. The knowledge of biology high school students are expected to know is divided and organized into a list of 27 curricular objectives (NCDPI, 1999). Since there are only 20 weeks (due to block scheduling, courses last a single semester) to teach the 27 curricular objectives, the list of curricular objectives becomes less of a guideline for teachers to follow and more of a directive that teachers must follow. Evident in David's use

of the verb *to do* as David describes his teaching; "I actually *did* all microorganisms in one full swoop" and "We only have two weeks left and I have still not *done* animals or plants;" is how the list of curricular standards became much like a "to do" list.

The pressure to cover the curriculum results in the value of time being determined by whether or not the class is moving down the list. In addition, the teachers receive pacing guides suggesting how many days the class should focus on each curricular objective in order to complete the entire curriculum in the allotted time. Taking longer than the suggested amount of time to explore a topic leaves teachers feeling like they are falling behind (McNeill, 2000). Therefore, if David spends an entire week allowing his students to come to understand the role of gene regulation and protein synthesis in skin cancer, he is less likely to be able to address all the other topics the students will be tested on. To prepare students for the test, the teachers choose to prioritize breadth and coverage over depth and coherence.

In four of the teachers' schools the students are given a practice EOC midway through the semester. The practice exam is based on the ordering of the topics outlined in the pacing guide. Therefore, if a teacher decides to take advantage of a current event or involve students in a larger inquiry, incorporating later curricular objectives earlier in the semester (like in Lucy's hurricane inquiry), he or she will not have addressed all the topics covered on the practice exam. Lower student scores are likely to bring negative attention upon the teacher. These practice exams became one more way the teachers' actions are subject to scrutiny; powerfully molding their actions and constraining their ability to teach as they think best (Foucault, 1975).

The constant shadow of the test prompts teachers to think of curricular topics in light of the EOC questions students are likely to see. Thus, as David is teaching genetics he wants

to be sure students are getting the information they will need to answer the types of questions they will see on the test. While the official biology EOC's are not published, there are sample tests available (www.ncdpi.org). I have included all the sample questions related to molecular basis of heredity in the box below.

Sample Biology End Of Course Exam Questions

1) During DNA replication, which of the following segments would be complementary to the original DNA segment of CCTAAT?

A) CGATTA B) GGUTTU C) GGATTA D) GGAUUA

2) What type of RNA is responsible for bringing amino acids to the ribosomes for protein synthesis?

A) messenger RNA B) transfer RNA C) ribosomal RNA D) mitochondrial RNA

3) The messenger RNA will carry the DNA's instructions out of the nucleus to which of the following?

A) vacuole B) mitochondria C) chloroplast D) ribosome

4) To determine the molecular sequence of a gene for a protein, which molecule should be analyzed?

A) tRNA B) ATP C) DNA D) rRNA

5) Transcription of the DNA sequence AAGCTGGGA would result in which of the following?

A) a sequence of three amino acids, linked by peptide bonds
B) a DNA strand with the base sequence TTCGACCCT
C) a mRNA stand with the sequence TTCGACCCT
D) a mRNA strand with the sequence UUCGACCCU

6) What is the purpose of transfer RNA?

A) It unzips the double helix so transcription can begin.
B) It retrieves amino acids from the cytoplasm for protein construction.
C) It carries genetic information to the ribosomes.
D) It produces a complementary copy of a strand of DNA.

(NCDPI, 2004)

In David's comment he reveals that he tries, "to give them as much information as [he] can," so they can, "figure out or at least recognize the answer." By examining the sample questions, it is easy to understand why he feels the best way to prepare students for the test is to teach the specific facts and terms, "piece by piece." The information the students need to know to answer these questions correctly is the names of the various enzymes involved in DNA transcription and protein translation, the sequence of steps involved in these processes and which enzyme is involved at which step. These abstract molecular aspects of genetics are far removed from how humans experience them. Answering the questions correctly relies solely on students having memorized the complex terminology and the specific steps.

If David's students learned about molecular genetics through an inquiry into the question, What's a little harm in sunbathing?, they would gain a conceptual understanding of how genes code for proteins, the role proteins play in regulating cellular division and the importance of these genes being tightly regulated for the health of the organism. None of the sample questions required students to understand these broader conceptual relationships or how the molecular processes relate to human health and disease. The more conceptual and relational understandings the students would gain from inquiry into the danger of sun bathing do not align with the understandings demanded by the test questions. Therefore, if David had decided to teach genetics through the sun bathing inquiry, he would still have to teach the specific names of the various molecules (DNA, RNA, ATP, amino acids), enzymes (messenger RNA, transfer RNA, ribosomal RNA, mitochondrial RNA) and organelles (mitochondria, nucleus, ribosomes, chloroplasts); the specific steps of DNA replication, DNA transcription and protein translation; as well as which RNA molecule does which step

and where in the cell each step occurs. Given the time restraints, taking the time to allow students to truly understand the connection between molecular genetics and their lived experience, while valuable to the students' engagement and learning, may harm their scores as other tested content will have to be sacrificed. Therefore, the easily testable aspects of the topics are granted priority over the broader, comprehensive understanding of how the information relates to other concepts and how it relates to human issues and concerns.

McNeill, (2000) during her research on teaching within an inquiry-based magnet high school that was being forced to participate in the state's high stakes testing program discovered similar incompatibilities between the understandings garnered through inquiry and those demanded by the questions on standardized science tests. Like this study, her research provides an up close analysis of why teachers choose teacher-centered pedagogies over inquiry-based learning for the sake of preparing students for a test. McNeill shares the story of a teacher who has always prioritized making connections between the physical science concepts in her curriculum and students' real world experiences. To help students understand the relationship between mass, inertia and work, she shows a video of car safety crash tests and poses students with the question, 'Why is the smaller car totaled while the larger car is merely dented?'. While the main concepts involved in this event (i.e. mass, weight, gravity, work, inertia) are covered on the test, they are presented as vocabulary terms to memorize and are often tested for what they are not: "Which of the following is not true of gravity?" In the test questions, the science concepts are not encountered as phenomena that are experienced, observed or explained (McNeill, 2000). Instead, the concepts are treated as isolated facts with specific definitions and students must know this basic information to choose the correct answer. Like the teachers in my study, this teacher changed her focus

from the real life events to the factual information and textbook definitions. The teachers find the tested curriculum so artificial that they are afraid the inquiry-based lessons would not result in students knowing the specific facts and definitions as they will be framed on the test.

All teachers believed that performing well on the EOC only requires that students be able to the recall and recognize the specific facts, terms and processes. In the rush to prepare students for the test, the accounts that give meaning to the concepts (i.e. their connection to one another, the human research narratives behind them and the ways humans experience them) are sacrificed. The phenomena of the natural world are divided into discrete, separate, objectives and are taught one by one in isolation of one another and from human experience. Therefore, in addition to tailoring their instruction to the content of the test, they are also tailoring it to the form of the content on the test (Calder, 1990; Cimbricz, 2003; Madaus, 1991; McNeill, 2000; Rottenberg & Smith, 1990; Shepard, 2000; Wideen, 1997).

Exclusion of students interests and needs

The large amount of information David is expected to teach, the lower order nature of the information prioritized on the test and the time restraints he faces discourage David from teaching in the student-centered ways he would like to. While engaging students in the sun bathing inquiry would allow his students to gain valuable understandings, it may harm their chance of earning a proficient score on the EOC. All of the teachers lamented that they were not able to support their students' understanding of information that relates most to their lives and are pressured, instead, to focus on information they see as less valuable (McNeill, 2000).

> This is the last time a lot of these kids are going to [take a life science course] and this may be their only opportunity to learn the details about why it's important not to litter. Let's teach them why they should not smoke and understand the science of how they can take better care of their bodies. The test asks the most worthless questions sometimes. Why does it matter that sponges came before earthworms? Why does this matter? (Sarah, Interview 1)

In this conversation, Sarah shared her frustration over the fact that the test asks students about the specific details of which organism appeared first while failing to prioritize the broader understanding of the nature of evolution and the large, diverse body of evidence supporting the theory. Furthermore, she, like the other teachers, is baffled by the fact that the aspects of biology students find most interesting (animals and human physiology) are rarely the focus of test questions. The teachers also argue that the pressure to focus on tested topics exclusively reduces their ability to take advantage of teachable moments and focus on real life event or the specific interests of their students (Romberg et al. ,1989; Rottenberg & Smith, 1990; Samiroden, 1990).

> If I had more time, I could spend time with the kids when they do enjoy something or if something biology related is in the news and get them to love science and see its importance. (Catherine, Interview 1).

> I wish I could focus more on the topics that are more interesting to the students. For example, many of the kids are really interested in biotechnology. They see CSI and find that interesting. They have all of that experience and motivation and they love talking about the ethical issues around genetic engineering. Some of the students who aren't into the science details and content, they really enjoy what laws are being made. They enjoy the more social political aspects. Unfortunately there is just no time to focus on these topics with all we have to cover for the EOC (Diane, Interview 1).

Given the time restraints they are under, there is little incentive and potential penalties for taking time to focus on a topic that is outside of the tested curriculum. Smith (1991) found, testing programs "significantly reduce the capacity of teachers to adapt to local circumstances and needs of pupils or to exercise any discretion over what to teach." (p. 10).

In the previous chapter, I discussed how the teachers successfully break away from the traditional conceptions of high school science by involving students in explorations of real-life events and issues, "decentering" (Barton, 1998) school science in ways that move the focus of the curriculum from the basic factual information toward students' lived worlds.

My study reveals how high stakes tests have enforced tight borders on school science, pressuring teachers to uphold the traditional version of school science where science knowledge is fact-oriented, decontextualized, rational and objective (Brickhouse, 1994; Cobern, 1996). As one teacher shared:

> I feel, if handcuffed is the right word, there is a little bit of being handcuffed to the test. If I veer off too much, I worry the students may not learn what they need to (Matthew, Interview 2).

High Stakes Pedagogy

The teachers in this study confess they are reluctant to use innovative instructional strategies (e.g., inquiry approaches, cooperative learning, student debates) and adopt more traditional instructional methods (e.g., lecture, recitation) due to the belief that these strategies will better prepare students for state tests (Cimbricz, 2003; McNeill, 2000; Romberg et al.,1989; Rottenberg & Smith, 1990; Samiroden, 1990). The teachers share that their typical teaching patterns for tested classes include lecturing while students take notes and engaging students in independent seatwork where they review the material. After a week or so of this routine, the teachers review all the material once more and give students a multiple choice test with questions similar to what they will see on the EOC.

All of the teachers' schools have moved to a block schedule where classes meet for an hour and a half each day for a semester instead of fifty minutes a day for a year. Teachers shared that being on a block schedule heightens their sense of time restraints as they must teach the entire curriculum in one semester instead of a year. The intention behind schools moving to block scheduling was to allow more class time for students to participate in extended investigations and work collaboratively. Ironically, when combined with the

pressure to prepare students for the EOC, implementation of block scheduling has had the opposite effect in the teachers' classrooms.

The major theme in the teachers' explanations of their teaching practices in their tested classes is efficiency as there, "is a lot of information students need to know and not a lot of time for them to learn it" (Lucy, Interview 2).

> I know students benefit from inquiry but it takes way too much time, way more time than I have to spend, giving them the time to research and learn about an event or topic or starting them on a lab and letting them experiment some. If I spend two days trying to get them to understand a small piece of the content, I am really rushed later because I have to get through all the stuff for the EOC (David, Interview 1).

> I would love for the students to get into groups, learn a topic and present it to one another. That means taking time out of class to do the research, time for them to meet in groups, time out of instructional time for them to present. I feel like they would benefit from things like that but, once again, it comes down to what is the fastest way to get across this piece of content. Sometimes more direct teaching works better because you only have so much time and you have so much material to cover (Diane, Interview 2).

The teachers also argue that the nature of the content prioritized on the test demands more teacher-centered, information transmission strategies. The only way for students to learn the abstract, factual information is to receive it from the teacher or the textbook.

One teacher revealed that her department had decided to omit all dissections because there are usually little to no questions on the EOC about animals. While dissections have been a part of biology classes at her high school for more than 30 years, they were omitted because they are seen as a waste of time since they do not correlate with the subject matter on the EOC. This is an example of how the focus on the specific subject matter of the test effectively separates student learning from their curiosities and actions. A review of literature on how high stakes testing is influencing science teaching that, "high stakes testing has led teachers away from strategies consistent with 'exemplary' science teaching" (Wideen et al, 1997).

Variations in testing pressure

Interestingly, there was one teacher who asserted that she was not going to let the test keep her from focusing on the topics the students find most interesting. She continues to teach aspects of human physiology and incorporates multiple animal dissections. I revealed to her how her view was unique and asked her why she feels she has reacted to the pressures of testing in a different way. She commented that her administrator does not pressure the teachers very much about the test. Her school is located in a rural area and falls within the median range for the state's test scores. Thus, they are above the score range where the school is in danger of being penalized and well below the score range for earning a "School of Excellence" standing. She believes her administrator is under less pressure and, therefore, so are the teachers at her school.

Alternatively, the teacher who taught at a school ranked in the top ten of the state (as determined by SAT scores) described intense pressure from her administrator and department head to focus solely on tested topics because the community expected their scores to be among the best in the state. This is the school whose science department decided to omit all dissections from their biology classes. This finding suggests that there may be increased pressure to teach to the test in the higher ranked schools, limiting these students' experiences with authentic learning. It also suggests that the impact of testing and the pressure high ranked schools are under to produce the top scores may reduce the differences in the types of educational experiences and curriculum knowledge students from different social classes receive (Anyon, 1980). This finding is unique within the literature on high stakes testing. Several studies have concluded that the effects of high stakes testing (i.e. narrowing of the curriculum and teacher-centered pedagogy) are more significant in poor, urban schools as

these schools are typically lower performing and, thus, in immediate danger of being penalized (Cimbricz, 2001, Kozol, 2004; McNeill, 2000). My study suggests, however, that the pressure to produce high scores in the higher ranked schools may have the same effect. This is ironic given the belief at the outset of accountability that the good schools with good teachers would not be impacted by accountability because they were already teaching the "right" way (McNeill, 2000). This assumption failed to predict how high stakes tests become the focus of learning, resulting in curriculum being focused on what is testable.

The implications of testing

As described above, testing has resulted in the prioritization on the basic facts, laws and theories. I will use a puzzle metaphor to conceptualize the reality of what happens when teaching becomes focused on delivering a series of predetermined facts and concepts. I picture the external reality of the world as a large puzzle full of the images of the world. Learning (both formal and informal) is the process of assembling this puzzle. Thus, the individual pieces of knowledge that allow us to know the world are the individual pieces of the puzzle. In our informal learning pursuits, we recognize that pieces are missing, we inquire into them, discover them and incorporate them into our personal puzzle. Therefore, over time, the complexity of the images in our puzzle is revealed.

The purpose of schooling is to support students as they assemble their personal puzzles. By the time students have reached school, they have already assembled much of their puzzle, enough to make out the general shapes of many of the images. To ensure that students assemble the most important images, schools have divided the puzzle (i.e. world) into sections (i.e. the various school subjects). To ensure that these sections are fully assembled, schools have identified all the individual puzzle pieces (i.e. curricular objectives)

that make up the sections. In our efforts to ensure that students are getting all of these pieces, the teachers hand students the pieces one by one. Everyone knows, however, that it is impossible to assemble a puzzle by being handed one piece at a time. Furthermore, it is impossible to assemble a puzzle if you have no conception of what the larger puzzle image is. Thus, the individual pieces have no value unless there is some knowledge of the broader image to which they fit. To the students, the pieces they are handed are irrelevant to the personal puzzle they have been assembling through their experiences in the world. The pieces they receive within schools are likely to be stacked to the side and forgotten.

The accountability and testing policies impacting the nature of teaching and learning in the teachers' tested classes are based upon the traditional positivist view of education. This view assumes that, as bodies of knowledge are discovered, proved, and accepted by society, they can be transmitted to students through generally passive instructional means (Dana & Davis, 1993). This approach has led to curricula that emphasize facts, laws, and rote learning. According to Johnson and Nicholls (1995), this traditional approach, which includes the constant effort of school systems to standardize information and instruction, has produced schools that center on the transmission, absorption, and repetition of noncontroversial information. Standardization and accountability are supported by the belief that intelligence depends upon a foundation of agreed upon basic knowledge deemed "essential" (Bloom, Finn & Ravitch 1987; Hirsh, 1987).

Dewey (1916) was clear in his criticism of such a view of education. Dewey (1938) insists that ideas, "cannot be passed physically from one to another like bricks; they cannot be shared as persons would share a pie by dividing it into physical pieces" (p 4). Dewey asserts that knowledge is not an ownable attribute or set of beliefs. It is an emotionally

charged activity. As the puzzle metaphor emphasizes, if the students do not know how the information they are learning about relates to their world and are not actively involved in the identification of missing pieces and then the pieces of understanding have no value in how they view the world.

In their non-tested classes, the teachers are able to connect with even their most disengaged students. While many of their students may continue to have low grades, due to failing to complete assignments, the teachers celebrate the fact that the students are engaged in classroom discussions and collaborative activities. Therefore, regardless of the students' ultimate grade in a course, they experience many moments of excitement and fulfillment from deeper understanding. According to Dewey (1938), every experience has continuity, it takes something from the past and leaves a "residue" that impacts the future. Therefore, even isolated incidents, especially interesting discussions, certain experiments, frog dissections, classroom animals, etc. have the potential to positively impact a student's attitude toward science.

Under the constraints of testing, however, teachers are less able to engage students in meaningful interactions with science. In their tested classes their students usually sit passively in their desks as the teachers deliver the information the students will be tested on. Evidence from past studies suggest that limiting instruction to teaching discrete facts and skills at the expense of greater inquiry in context can place at-risk students at greater risk of failure (Charlesworth et al., 1994; Hilliard, 2000). The irony of dilemma the teachers face, however, is that failing to teach the discrete facts and skills also puts students at risk for failure as students' grades are connected to their performance on the EOC.

The dilemmas of testing

The existence of high stakes tests has resulted in teachers facing an ethical dilemma. The dilemma they face is greater than the problematic situations teachers face in the ongoing negotiations of classroom life (Cuban, 1992; Lampert, 1985). Katz and Rath's (1992) use of the term is more appropriate to the nature of the dilemma the teachers in this study face:

> The term dilemma refers to a predicament that has two main features…(a) It involves a situation that offers a choice between at least two courses of action, each of which is problematic, and (b) it concerns a predicament in which the choice of one of the courses of action sacrifices the advantages that might accrue if the alternative were chosen. In sum, a dilemma is a situation in which a perfect solution is not available. (Katz and Raths, 1992 p. 377)

When the teachers teach a course subject to an end of course (EOC) exam, they face an ethical dilemma between focusing their lessons on students' interests and experiences or on the factual information their students will be tested on. The teachers find the tested curriculum so separate from students' experiences that they are not confident they can cover the information the students will see on the test if they utilize their preferred inquiry pedagogies. Focusing exclusively on the tested curriculum, however, robs their students of experiences and understandings the teachers value. While the teachers want to focus on the aspects of science that are most relevant to students' experiences and develop the understandings and habits of mind they see as most valuable, they had to examine the costs for themselves and their students. In the end all of the teachers admitted to organizing their instruction in ways they felt would prepare their students for the test even though this results in them teaching in ways that go against their beliefs. As Diane commented, "the test keeps you from being able to do things that you think are best for your students or doing things that would engage your students." (Diane, Interview 2)

Conclusion

My goal for this research study was to identify the challenges the teachers face as they attempt to implement their reform based goals and how these challenges have influenced their practice. My findings reveal that the greatest challenge the teachers confront in engaging their students more actively in their science learning is the curricular constraints they face from mandated curricula. In many instances within their non-tested classes, they are able to overcome this challenge by focusing on the connections between their students' lives and the content of their curricula. In their tested classes, however, such adaptations could be costly to themselves and their students. In this chapter I have explored how the teachers' curricular freedom is reduced by the abstract, factual focus of the EOC. The topics prioritized on the test are so removed from lived experience that teachers do not feel their students will learn the information they need for the test if they teach through their preferred inquiry pedagogies. Furthermore, the size of the tested curriculum and the time restraints they face prompt the teachers to utilize the more efficient teacher-centered pedagogies focused on information transmission. My study adds to the literature on high stakes testing by providing a nuanced, detailed discussion of how high stakes testing results in significant changes in teachers' classroom practice. My findings permit a comparison to be made between teachers' practice in their non-tested and tested classes. Therefore, they provide valuable insight into just what is lost when teaching becomes focused for a test instead of teaching for students.

CHAPTER SIX

DISCUSSION AND IMPLICATIONS

Science education reform initiatives demand a shift in emphasis from teachers presenting information and covering science topics to students discovering such information on their own, through inquiry (AAAS, 1990; NSTA, 1991; NRC, 1996). The *National Science Education Standards* (NRC, 1996) insists that learning science should be an active process, something that students do, not something that is done to them. There is little research, however, on the nature of the challenges science teachers face as they attempt to implement these reform goals within the typical contexts of high school science classrooms (Crawford, 2000; Keys & Bryan, 2001; Songer, 2003).

I invited six teachers who left their teacher education program passionately voicing their intentions to teach in a reform-based manner to participate in a series of open ended interviews. Through these 'purposeful conversations' (Burgess, 1988), I invited the teachers to share the challenges they have faced as they attempt to enact reform ideals and describe how these challenges influence the extent to which they are able to implement reform within their classrooms. During our conversations, the science teachers shared many examples of how they have implemented the ideals of science education reform within their classroom practice. In addition they discussed how the curricular constraints they are under present significant challenges to their ability to implement the ideals of reform on a consistent basis. The accounts the teachers shared offer a unique insight into how they interpret and negotiate the challenges of reforming science teaching within current high school classrooms.

Reaching goals and coping with challenges

Unlike the large body of research (Benson, 1999; Carlsen, 1991; McDairmid, 1990; Pajares, 1992; Rusk, 1994; Wideen, et al., 1998; Zeichner and Tabichnick, 1985) concluding that beginning teachers fail to maintain the student-centered and reform-based beliefs they hold when they leave their teacher education programs, my teachers continue to support a reform-based vision of teaching. The teachers' main goal is getting students more actively engaged in their science learning, which is the main theme of science education reform. The teachers also strive to develop students' habit of questioning why things are the way they are and developing their desire to learn more about the science in their lives. Many of the teachers connect their teaching actions to preparing students to be able to make personal and societal decisions related to science. Instead of focusing their teaching goals on developing student mastery of the basic concepts of the curriculum (Tobin, et al. 1994), all teachers hold broader goals focused on developing the attitudes and abilities aligned with the conception of scientific literacy within the science education reform initiatives (AAAS, 1990; NSTA, 1991; NRC, 1996).

In this chapter, I discuss the challenges teachers face as they strive to enact their teaching goals and the impact these challenges have on the development of their practice. I also explore how my findings align and differ from other literature on beginning teachers and science education reform. As discussed in Chapter 5, the presence of high stakes tests prompts teachers to teach in ways that go against their beliefs. Therefore, bureaucratic control of the curriculum through accountability policies and high stakes tests emerged as the most powerful challenge the teachers face. Five of the six teachers confess that the pressure to prepare students for tests effectively prevents them from acting on their teaching goals in a

substantial way within their tested classes. Thus, the teachers' experiences in their tested classes do not permit an exploration of how the teachers implement their reform-based goals or the ways in which their practice has been influenced by both reform and contextual challenges. Therefore, I first focus on teachers' experiences in their non-tested classes. After I have discussed the teacher's experiences within their non-tested courses, I will focus my discussion on the implications of high stakes testing for teacher practice and student learning.

The evolution of teaching practice

While the teachers left their teacher education program intent on enacting the ideals of reform, they admit to relying on more teacher-centered methods during their first year of teaching. As the they struggled to adapt to the complexities of teaching, they described common challenges of beginning teachers such as a lack of knowledge of the curricula; a lack of resources, particularly a lack of student-centered curricular resources; classroom management problems; and a lack of student engagement (Flores, 2003). In reflecting on their first year actions, the teachers recounted their early experiences with attempting reform-based strategies. All teachers described being shocked and dismayed by the lack of engagement their students demonstrated towards the strategies that had been presented in their methods course as methods to actively engage students. In Chapter 4, I shared David's experience with the discrepant event involving balloons expanding and shrinking in hot and cold solutions. While this constructivist based lesson aims to involve students in questioning and hypothesizing about the science behind the phenomenon, the students showed little interest in knowing the scientific theories. Instead of students participating in the ways the teachers thought they would, the students were often passive or even resistant. The students'

reactions to their lessons were central to teachers' early analysis and reflection upon their practice.

Research on beginning teachers reveals that teachers often respond to student resistance and disengagement by questioning the applicability of reform-based strategies to their contexts and making their practice more traditional and task-oriented (Alves, 2001; Flores, 2003; Gibert & Yerrick, 2001; Huberman, 1991; Marcelo, 1994; McNeil, 1986; Olson & Osborne, 1992; Vonk, 1993). The changes the teachers describe making to their practice differ from the typical accounts within the literature on beginning teachers. The teachers interpret the challenges they faced in a unique way. They acknowledge the role the curricular content plays in students' resistance and, therefore, do not resort to teacher-centered strategies to handle student resistance (Burk and Fry, 1997; Flores, 2003; Puk and Haines, 1999, Powell, 1997).

As the teachers struggled with the complexity of engaging their students, their reflections focused on the nature of the content they are expected to teach. They concluded that the basic science knowledge as outlined in their curricula and described in their textbooks hold little value for their students. They insist that their students are interested in learning about the science that relates to their lived experiences. Therefore, teaching the highly specific curricular standards outlined in their Standard Course of Study is an obstacle to them actively involved students in learning.

The teachers work toward reframing the content of their curricula to elicit more involvement from students. They do so by focusing classrooms discussions and inquiries on the connections between the subject matter and real life events. Science teachers, especially at the secondary level, are often found to portray science as a decontextualized, objective

body of factual knowledge (Brickhouse, 1994; Cobern, 1996; Gallagher, 1991, Tobin, 1994, Yager, 1990). The teachers in my study, however, engage students in explorations into the human research narratives and controversies behind curricular concepts. In Chapter 4, I discuss several of the lessons teachers share as examples of ways they utilize reform ideas and successfully implement their teaching goals. The teachers involve their students in questioning the science behind real life phenomena such as hurricanes and tsunamis and the science behind current news stories such as an oil spill and a claim of human cloning. Furthermore, they use scientific representations in films to prompt students to question the scientific concepts and inquire into the nature of science knowledge. The ways in which the teachers have reframed their curricula to highlight the connections between the content and lived experience align with recommendations for supporting the learning of students who have been traditionally excluded from school science (Atwater, 1996; Barton, 1998; Brickhouse, 1994; Cobern, 1996; Cole, 1998; Hofstein and Yager, Eisenhart, 1996; 1982; Lee, 1999; Rodriguez, 1998; Seiler, 2000).

The teachers describe how they have become more flexible in their teaching and more responsive to student interests. Thus, their conception of student-centered teaching expanded from a focus on a set of teaching methods to a broader conception of how their students' interests and desires relate to scientific knowledge. The teachers insist that the most valuable science knowledge is that which students will need for their future lives. Furthermore, they insist that positive attitudes toward science and abilities to critically assess scientific information are more valuable than a set of scientific understandings. When asked how they would create the science curriculum if they had the power to do so, the teachers proposed a curriculum focused on everyday student experiences and science related societal

issues. They insist that such a focus would engage a wider range of their students than they are able to reach with the mandated curricula they are currently hired to teach.

Testing and control

My study exposes beginning teachers' commitment to and ability to implement many of the ideals of science education reform within the contexts of their classrooms. It also offers a sobering view of how recent accountability policies are preventing teachers from acting on these reform-based beliefs and abilities. Issues of accountability, public scrutiny and control over curriculum surfaced as the most significant obstacle the teachers face as they attempt to implement their reform-based goals. As in their non-tested classes, the crux of the challenge teachers face involves the lack of relevance of the curriculum. The aspects of science knowledge the teachers believe are most valuable for students do not align with the scientific understandings demanded by the test. The nature of the tested content is often separate from how humans experience it. Therefore, the teachers fear they will not prepare students adequately for the test if they utilize their preferred inquiry-based pedagogies (McNeil, 2000). The obligation teachers feel to focus on the tested curriculum reduces their ability to adapt the curriculum to the needs of their students (Samiroden, 1990; Smith, 1991; Wideen, 1997).

The teachers face an ethical dilemma between teaching students in the ways they believe are best or teaching in the ways that they feel will best prepare the students for the test (Barksdale-Ladd & Thomas, 2000; McNeill, 2000). The stakes involved in the test heighten the intensity of the dilemma the teachers face. All but one of the teachers confessed to focusing their teaching almost exclusively on the understandings students will need for the test and focusing their practice around the efficient delivery of this information. Unlike in

their non-tested classes, where the teachers focus on the connections of the content to students' lived experience, the teachers focus exclusively on the factual information. They reveal that the significant time restraints they are under prevent them from being able to highlight the connections between the isolated facts and the students' experiences in a substantial way.

Earlier, I argued that my findings differ from most of the research where beginning teachers are socialized into the traditional norms within their school (Burk and Fry, 1997; Flores, 2003; Puk and Haines, 1999, Powell, 1997). However, in their tested classes, the teachers do comply with these traditional norms. Their compliance with accountability could be seen as a way they are socialized into the standard ways of schooling. The teachers' comments, however, indicate that the effects of the test have actually fostered the teachers' non-traditional, reform-based beliefs. While they are not free to act on these beliefs in their tested courses, they do act on them in their non-tested courses.

The voice-centered relational method (Mauthner & Doucet, 1998), which is the method of data analysis I utilized, focuses on connecting teachers' narratives to the broader social, political and structural contexts in which they work. Therefore, I paid close attention to how and when the teachers alluded to testing in their comments. What became evident was how they often define their personal views of teaching in opposition to the traditional conceptions of teaching and learning the testing policies are based upon. Their comments suggest that the prioritization of the discrete, factual information on the test prompted their recognition of its lack of value for their students and their commitment to focus on more valuable knowledge when they are able to do so. A few examples of the specific comments that suggest this are:

> They had to know the parts of the cell. Well, please, I drilled that into their heads so many times. It was so boring. I was like, why do they have to know the parts of the cell? How is this information going to help them one iota in life? (Sarah, Interview 1)

> There is a lot of stuff about biology that I think an everyday person should probably learn about and know just for living out their lives. Students don't really need to know the equation for photosynthesis, but they do need to know what HIV and AIDS are and the fact that there are millions of people in Africa dying from it. I think that is more relevant than memorizing the equation for photosynthesis. (Diane, Interview 2)

In these comments, the teachers define what they see as valuable in opposition to the information that is prioritized on the test. While the impact of the test constrains teachers' ability to act on these beliefs, it also appears that the test has enabled the teachers to refine their beliefs. Furthermore, their lack of ability to act on their beliefs in their tested classes could function to increase their commitment and desire to act on them in their non-tested classes. Perhaps their negative experiences under the control of testing offers some explanation for why the teachers show the unique commitment to enacting reform goals in their non-tested classes. The negative impact of testing could actually have a positive impact in the long run by fostering critical reflection on the goals of education and a greater awareness of the difficulty of these goals being assessed by students' choice of one of four answers.

Testing and Democratic Education

The most significant challenge the teachers face in developing their practice around the needs of their students is the obligation they feel to prepare their students for high stakes tests. The shift in focus within their tested classes from preparing students for future life to preparing students for a test has a significant impact on the types of science learning experiences student have. As Dewey (1938) argues, while the specific concepts of the curriculum may be forgotten over time, the means to those ends result in a "deposit" or

"residue," that affects students' future experiences (p. 48). Therefore, Dewey emphasized the importance of the abilities the students gain by the *ways* in which they interact with the curriculum and the types of experiences they have in classrooms, what he refers to as "collateral learning" (p. 48). In the following discussion, I explore the collateral learning resulting from the tested and non-tested science classes and examine the influence testing is having on the development of students' ability to participate as citizens in our democracy.

While I have a strong interest in democratic education, I did not expect that I would be discussing the topic in the context of this dissertation. However, as I listened to the lesson descriptions the teachers shared within their non-tested classes, the connection of their teaching strategies to those supported by democratic educators was immediately apparent. Furthermore, their use of these strategies represents how they go beyond the conceptions of science education reform presented in their methods course and engage their students in lessons that support the development of their democratic capabilities. I was also struck by the degree to which the teachers' practices in their tested biology classes effectively remove students' voices from the classroom. Therefore, my interest in discussing democratic education is also motivated by my desire to highlight what is being lost in the name of testing.

As I listened to the teachers describe the lessons they engage their students in within their non-tested classes, I was struck with how their lessons align with the active, problem posing strategies supported by critical and democratic educators (Dewey, 1916, 1938; Freire, 1970; McLaren, 1989; Shor, 1992). In their non-tested courses, the teachers involve students in asking questions, making sense of their experiences, assessing data to come to their own conclusions and critically analyzing the validity of information. The teachers strive towards

more participatory models of teaching, engaging students in learning science through dialogue and debate with one another.

Shor and Freire (1987) argue for education, "starting from student descriptions of their daily life experiences…starting from concreteness, from common sense, to reach rigorous understanding of reality" (p. 20). Many of the lessons the teachers shared focus on engaging students in inquiries into current natural events. One example is Lucy's class inquiry into predicting the path of the hurricane. The students' innate curiosities were tapped as they worked to make meaning of what they already knew about hurricanes while expand their understandings in ways that illuminate the scientific knowledge. In this participatory way of teaching, the students utilize their own words, themes and experiences to gain an understanding of the academic knowledge of the curriculum. The students are challenged to go beyond themselves into a new territory where, "the two separate universes of academic discourse and student speech end their isolation and reinvent a 'third' discourse" (Shor, 1992, p. 77).

Matthew's use of *Jurassic Park* (Spielberg, 1994) is a great example of participatory problem solving (Shor, 1992). As discussed in chapter 4, he showed students a clip of the film where there were dinosaurs hunting in a pack and poses the question of why the dinosaurs are presented in the manner that they are. The students were given packets with the fossil evidence available for the dinosaur species and asked to come to their own conclusions about whether or not they think the representation in the movie is an accurate portrayal. In the lesson, Matthew took the remote knowledge, i.e. the static description of a dinosaur species, and presented it problematically. The students were encouraged, "to think critically so they might give their own interpretations to the data" (Freire, 1973, p. 124). The students

learned about the use of fossil evidence, which was the curricular objective, while learning about the tentative nature of science knowledge and gaining practice in questioning scientific representations. The students also read articles written by a scientist who argues that the accepted representation is inaccurate. Thus, the students are able to connect human beings and human emotions to scientific understandings and participate in the ongoing debate. Therefore, what is usually presented in a textbook in an objective, decontextualized, and emotion-evacuated form is transformed into an actively debated issue among a community of debating scientists (Dewey, 1916). The students gain an understanding that science is not a separate, objective or irrefutable body of truth, that there are controversies and ongoing discussions about the scientific representations in which they can participate.

Like Matthew, Sarah engaged her students in critically analyzing information. One of the lessons she shared also allowed her students to consider how scientific representations can be used toward political and financial aims. As discussed in chapter 4, Sarah focused her class on an article written by Exxon claiming that the region around the Valdez spill has recovered completely. Through their research, the students discovered that those species most sensitive to pollution continue to exhibit reduced populations, while the statistics Exxon chose to utilize in the article focus on the organisms least affected by pollution. In this lesson, the students learned about the impact of pollution on different organisms, while also gaining an understanding of how statistics can be used to misrepresent reality and how information presented as scientific can actually be propaganda towards political and financial goals.

In the lessons discussed in chapter 4, students were challenged to explore events and issues and after doing so formulate their own opinions, often in cooperation with others.

Dewey (1916) supported that education should be focused on fostering students abilities to work together to solve problems, to think creatively and critically and for acting in concert with others toward common aims. His view of education focused on developing the habits of mind, not the accumulation of knowledge of the specific subjects. Dewey saw democracy as more of a social ethic than a form of government. He supported that an awareness of one's interdependence with others; the capability to make meaning of situations and problems and the ability to communicate effectively with others through discussion, dialogue and debate are essential for democratic citizens. With these democratic habits of mind, they are equipped to work with others toward the continual readjustment of society in ways that improved society for all its members.

Residues of testing

In contrast to the active, questioning, debating students within the non-tested course lessons described above, David described his biology students sitting passively, listening as he lectured on how the messenger RNA molecule carries the transcribed strand of DNA from the nucleus to the ribosomes. His students are not likely to be aware of how this information connects to their lived experience. The information they learn in their biology classroom is separate from the discourse and knowledge of their daily life. They are expected to learn it because the teacher demands it and David demands it because it is demanded of him. As Shor (1992) argues, *"*to teach skills and information without relating them to society and to students' contexts turns education into authoritarian transfer of official words, a process that severely limits student development as democratic citizens" (p.44).

With a lack of emphasis on ownership of ideas and the personal construction of knowledge, the students learn to depend on their teachers and texts for answers, rather than

relying on their own judgment and common sense (O'Loughlin, 2000). According to Dewey (1916), this kind of emphasis negatively impacts students because it promotes an external imposition on them in a way that limits rather than promotes their intellectual and moral development. In the tested classes, students are passive agents. Not only are students aware of their powerless position since they have no control over the information that is being delivered to them, they also see their teachers in the same situation. They learn that being powerless is not limited to children and adolescents. Unfortunately, the unilateral authority of the banking model, which both the teachers and students are subject to, becomes the normal way things are done (Freire, 1970).

The promotion of dependency on outside authority is particularly disturbing given the current "widespread sense of political alienation and mass rejection of participation in public life" among young Americans (Sehr, 1997, p. 13). The result is that American life will continue to be shaped by default by the powerful elite. The students will move from their schools where they receive information passively to their living rooms where they will passively receive information from the large corporations that control the mass media. Since their experiences have been dominated by them passively accepting unquestioned information they are likely to continue these behaviors in their adult lives. They are unlikely to enter the public life of their community and work toward ensuring that a wider band of society will have its interests served. Therefore, the implications of my study go beyond the scope of students' scientific literacy and teachers' use of reform to the ongoing struggle for equity within our nation.

IMPLICATIONS

This study adds to the small body of studies that reveal a more progressive pattern of change than is typically identified in beginning teacher research (Hebert and Worthy, 2001; Solmon, Worthy & Carter, 1993). The teachers' successful inquiry lessons highlight avenues of reform within the typical contexts of high school science classrooms. The teachers' experiences also provide insight into how reform efforts can be focused to expand the role of inquiry within secondary science classrooms. The insights gained from this study have implications for future science education reform efforts, for science teacher education programs as well as for research on teaching.

Implications for science education reform

The *National Science Education Standards (NSES)* (NRC, 1996) emphasize that "science is for all students" and "emphatically reject any situation in science education where some people are discouraged from pursuing science and excluded from opportunities to learn science" (p. 20). The teachers in this study argue that the ways we define school science is responsible for discouraging and excluding many of their students from opportunities to learn science. Furthermore, the lack of relevancy that curricular topics have to students' lived experience reduces their ability to learn them through inquiry. Without exception, when asked their opinion on how science education reform efforts could be focused to support their students' learning, the teachers replied by making the curricula more relevant to students' lives.

The teachers argue that curricular decisions should be made on the basis of relationships to real-life problems, current issues and concerns (Yager 1996). While the *NSES* (NRC, 1996) insists that science content should be cast in real-world issues, and

questions arising from personal curiosity, they also provide a list of content standards for each of the separate disciplines. Therefore, the *NSES* have not created the content standards on the basis of relationships to real-life problems and issues. Instead the specified list of scientific concepts offers a minor change from the typical curricula focused on understanding science for its own sake (Rodriguez, 1998; Seiler, 2000). The *NSES* do not address how teachers can respond to student interests and real life events when learning outcomes are so clearly defined (DeBoer, 2002). The teachers shared that the obligation to teach a large amount of predetermined information restricts their ability to engage their students in extended inquiries. My findings reveal the importance of teachers being able to adapt the curriculum to their students' needs and interests and respond to local and global science events and issues. The results of my study suggest that science education reform should reconsider the position that scientific literacy requires a specific body of predetermined knowledge. If efforts are not targeted toward reforming the nature of the high school science curriculum, inquiry based learning may only be implemented during the occasional moments when high school science intersects with lived experience.

Implications for science teacher education

As described in Chapter 4, the teachers entered their classrooms with the belief that using certain teaching methods is the key to engaging students more actively in science. The teachers did not have the opportunity to consider how such teaching strategies are challenged by the previous learning experiences of students, by the students' science related interests and by the nature of the curricula they will be expected to teach. Ultimately, they had to negotiate the challenges and navigate between the ideas of reform and the characteristics of their students and contexts with little to no support. While we want teachers to encourage

their students to critically analyze information, we often fail to follow our own recommendations with preservice teachers.

My study suggests that teachers should be encouraged to reflect and critically analyze the nature of the contexts in which they will be teaching. For example, the teachers were aware of the existence of the EOC before they entered their classrooms, but were likely shielded from the intensity of the pressure while student teaching. It is important for them to reflect on and seriously discuss the impact high stakes tests will have on their teaching. Furthermore, the teachers could have benefited from an opportunity to critically analyze the nature of current high school science curricula, the limitations inherent in how high school science has been defined and how the content intersects with their future students' needs and interests. There were no discussions of the fact that many of their students might not be interested in learning the factual information contained in their curricula and outlined in their textbooks.

While social justice was a theme in the teachers' education program, this theme was not incorporated within the science methods course. Therefore, the relationship between power and knowledge and the ways schools function to stratify society and marginalize certain students were topics of discussion within the teachers' foundation class and multicultural education classes, but were not applied to discussions of school science in their methods course. Banks (1989) described four approaches for including ethnic and cultural content in the curriculum. The first approach adds contributions, heroes, celebrations and people to the curriculum on special days. The second, additive approach, attaches content, themes, and perspectives to the curriculum without altering its structure. The third approach, transformation, changes the curriculum so that students get multiple viewpoints about an

event or a finding. The final approach, decision making, allows students to identify their own social or environmental problems so that they can clarify their values and understanding of the problems. The approach taken in the teachers' methods course aligned with the most basic approach. The two articles the teachers were assigned on multicultural education focused exclusively on listing the scientists and scientific accomplishments of non-white, non-male scientists. The articles did not raise questions about the nature of the curriculum or whose norms and values it supports.

The teachers were able to adapt their curricula in ways that increase its cultural validity relative to the world outside the classroom, but it does not appear they make attempts to increase the cultural validity of their curriculum toward the ethnic diversity of their students. The teachers refer to their students in reference to two seemingly homogeneous groups; the college bound and non-college bound. The non-college bound students were grouped together and the teachers only made reference to a students' minority status when speaking of the challenges of teaching English language learners. The teachers' accounts reveal their limited awareness of their students' distinct cultural identities.

Eisenhart (1996) argues that opportunities to practice 'real science' are not likely (alone) to increase the chances that students will want to or be able to use academic science in their lives beyond the school. Furthermore, she contends that educational reform can be transformative only to the extent it creates an inclusive system where culturally relevant world knowledge and ways of knowing are reflected in what is to be known (p. 271). Despite the teachers' efforts to reduce the marginalization of their students, their lack of attention to the diversity of their students may hinder their ability to make connections between scientific ways of knowing and the students' personal ways of knowing. This

finding provides support for a greater emphasis within science methods courses on critical science education and multicultural science education.

Implications for classroom research

I believe the findings of my study highlight the importance of extended, interactive conversations with teachers to allow for their understandings and interpretations to be incorporated into the research knowledge. As I argue in my literature review and in the methodology chapter, teachers' perspectives have been largely dismissed and excluded from research on educational reform (Gitlin, 1990; Zeichner and Gore,1990). As I explored the literature on beginning teacher research, I was struck by the deficit discourse aimed at teachers. For example, Flores (2003) conducted a study very similar to mine focusing on how teachers' ideas beliefs about teaching changed over a two year period. From two semi-structured interviews, Flores identified four teachers who professed to using student-centered strategies while the other ten described feeling no choice but to rely on more teacher-centered methods. She remedies the differences between these two sets of teachers with the following conclusion, "Clearly this study identified the differences between teachers who were enthusiastic and committed to teaching and learning, and those who adopted a more compliant and 'giving up' attitude (Flores, 2003 p. 25). Flores mentions the contextual challenges the teachers described at one point in her findings which include accountability and curricular restraints. However, she does not explore them further or make a connection between the contextual challenges the teachers' describe and their accounts of their practices. Instead, she focuses exclusively on the teachers and their beliefs. Research that prioritizes research theories over the voices of teachers explaining their realities will fail to understand

the nature of the challenges teachers face (Gitlin, 1990). Without understanding these challenges, we have little hope of addressing them.

Given that my study was based on a series of interactive, open-ended interviews, I was able to engage teachers in extended conversations where we mutually explored the meaning of their ideas and experiences for themselves and their practice. I believe these ongoing conversations were essential for illuminating the complexity of the challenges the contexts of schools present to inquiry-based learning. Each conversation allowed me to understand the nature of the dilemmas and challenges the teachers face in more detail. Had I solely observed the classrooms of the teachers, I would have likely observed their tested, biology classes since that is my specialty area. I could have written a critique of their instructional methods as so many researchers have. Thus, I would have used my power as a researcher to make claims about them and their teaching without assessing their knowledge about why they teach the way they do.

Limitations

There are several limitations of this study. First, the data was limited to teachers' reports of what they do in their classroom. Therefore, there is no data available on how the students' experienced the lessons and whether or not what the teachers perceived as successful are perceived in the same ways by students. The fact that I was involved in their teacher education program and was their student teaching supervisor may have prompted teachers to accentuate the reform-based aspects of their practice while downplaying aspects that do not align with reform models.

The second limitation is the limited sample size. With only six teachers, it is difficult to illuminate the variability and diversity of teachers' experiences and practices. The

teachers in my study reported similar teaching goals and similar contextual challenges. A larger sample size would likely have provided greater variability and could have highlighted important issues and challenges that did not arise in this small group of teachers.

A third limitation is the lack of variability in the teachers' school contexts. Five of the six teachers taught within large high schools in mostly suburban districts surrounding a large metropolitan area within central North Carolina. One teacher taught in a school in the western portion within a smaller city that draws students from more a more rural area. In comparison to the rest of the state, the teachers' schools are less diverse both in terms of race and socio-economic class. While the teachers feel their curricular resources, particularly resources related to more student-centered teaching, were limited, they did have rich access to technological resources such as computers, televisions and computer labs. Five of the six teachers have access to a computer and internet connection within their classrooms. Therefore, my study does not provide insight into the particular challenges of implementing science education reform ideals in predominantly urban and rural schools, schools with limited resources or schools with a more diverse student population.

My study is also limited by time. As I continue to maintain relationships with the teachers, the nature of their contexts continues to change and their teaching practices continue to evolve. Many of the teachers commented that their conversations with me helped them to reflect on and refine their goals. In addition, reading my research summaries provided them a perspective on their situation that they had not previously had. Three of the teachers indicated that the connection I make between their inquiry-based lessons and students' democratic capabilities highlights the importance of their teaching decisions and has prompted them to incorporate more inquiry into their teaching.

Since my interviews with the teachers, an earth science EOC has been created and is in the pilot stage this school year. When the earth science EOC is implemented in the 2007/08 school year, the teachers will lose the curricular flexibility they credit to their ability to utilize inquiry. Therefore it is probable that the moments of successful inquiry the teachers were able to create in their earth science class will end upon the implementation of the earth science EOC.

Future research recommendations

This dissertation offers insight into six teachers' experiences as the attempt to implement reform based ideals within their secondary science classrooms. Further research would be useful in expanding and deepening the findings of this study. In this section I offer some suggestions for future research.

There is very little research on the nature of the challenges science teachers face as they attempt to implement reform goals within the typical contexts of high school science classrooms (Crawford, 2000; Keys & Bryan, 2001). Therefore, one of my recommendations is for more studies on secondary science teacher committed to implement reform that prioritizes the perspectives and understandings of the teachers. First, research on more diverse school settings would reveal the unique challenges to reform-based teaching within urban and rural settings as well as how teachers have adapted their curricula in ways that highlight connections between the curriculum and students' diverse cultural ways of knowing. In addition, more intimate case studies of individual teachers would illuminate the reality of the specific challenges the teachers face in their day to day planning. Furthermore, classroom observations could provide insight into how students' respond to inquiry activities and how both teachers and students mediate the unique challenges of inquiry instruction.

Such research could provide more detailed descriptions of the teacher-designed inquiry lessons, illuminating models of inquiry based learning that are relevant to the contexts of secondary science classrooms. Finally, a longitudinal study that examines how teachers' use of reform based strategies evolves over time would be particularly informative to the current literature on science education reform.

This research has centered on the experiences of teachers. During our conversations, the teachers spoke of the impact they feel the inquiry-based lessons had on students' science attitudes and science learning. A particularly important route for future research, therefore, is exploring students' perspectives of the teacher designed inquiry lessons. Erickson and Schultz (1992) conclude that student experience of curriculum has received negligible attention from both educators and researchers. Since teachers were adapting their curriculum in way they perceived would increase student interest, it is essential to understand the students' point of view. A focus on the students perspectives can highlight the challenges they face in inquiry instruction and how inquiry can be implemented in ways they find most engaging.

Final reflection

As I finish up this dissertation, the teachers are in their classrooms struggling to engage twenty-six different students about some topic in science. Unfortunately, my study reveals that the structures and policies within their schools offer more challenges than support. As I explored the teachers' experiences, I was saddened by how many obstacles then teachers face as they strive to reach out to their students and provide them with valuable understandings. Thus, writing this dissertation has been bittersweet. While I celebrate my accomplishment, I must remain committed to the teachers who made this work possible. It

would be an injustice to the teachers if the knowledge they so generously shared with me remains confined to the words on these pages. This study has highlighted the political nature of educational research and the sense of obligation I have to use my findings to support change and advocate for teachers. My research journey began over three years ago when a student, attempting to be a scholar, was happy to find her voice until she discovered that this voice was silencing the voices of others. This study has allowed me to be an advocate for teachers and to use my voice in ways that will support teachers and work toward change and incorporate the voices of teachers within the understandings of science education reform.

Appendix 1:

Reflections on Data Analysis and Presentation

Introduction

In this reflection, my goal is to provide greater transparency to how the research narrative of this dissertation emerged from my conversations with science teachers. I acknowledge that the creation of the text of this dissertation was a highly subjective and interpretive process influenced by a variety of influences. Specifically, my data analysis and presentation were influenced by three separate voices; my own, those of the teachers, and those of researchers whose work has influenced mine. As Mauthner & Doucet (1998) share,

> At the end of the day, whether we consciously/explicitly or not, we are in effect choosing a particular theoretical and ontological framework within which to locate ourselves, and through which to hear and analyze our respondents' lives. The difficulty is not so much the choice of paradigm, but rather having to accept that this is the case and that as a result we will focus our attention on certain issues and perhaps ignore others. The best we can do then is to trace and document our data analysis processes, and the choices and decisions we make, so that other researchers and interested parties can see for themselves some of what has been lost and some of what has been gained. (Mauthner & Doucet, 1998, p. 137)

Data analysis details

Even though I draw on previously described methods of data analysis (described in detail in Chapter 3), I used them in my own way and in the ways I thought best for the broader goals of my research. My goal for this discussion is to reveal the complexity of my data analysis as well as provide greater transparency on how my data analysis decisions were guided by the broader motivations of my research. One of the major ways my data analysis was influenced by feminist epistemology and feminist research theory was how I acknowledged and embraced the significant role my own personal biography played within the analysis and representation of the teachers' stories. My personal, political and theoretical

biography influenced why I wanted to learn from the teachers in the first place as well as what aspects of their stories I saw as most significant. Feminist researchers acknowledge that their personal experiences are an asset to their work, not something that must be repressed for the sake of maintaining a illusion of objectivity (Reinharz, 1992). I will go into how I see my biography influencing how I created the narrative of this study below as I discuss why I chose to tell the story I did.

My awareness of the role my own ideas play in my research was part of the reason I was so attracted to the voice centered relational method (Mauthner & Doucet, 1998). As described in Chapter 3, this method involves multiple reviews of interview transcripts. During the first review, I focused on assessing how I responded emotionally and intellectually to the person and what they were saying. Specifically, this review allowed me to identify when I naturally felt doubt about something a teacher said, places where their conclusions did not make sense to me as well as places where their comments seemed extra significant. It became clear that I found their comments more significant when they strongly agreed or disagreed with my own assumptions as well as with the ideas of other researchers and theorists to which I am familiar. By paying close attention to how I personally reacted to their comments, I was able to identify assumptions I have, reflect on these and document them so they could be explored more in subsequent conversations with the teachers. For example, one of the major themes of my initial conversations with teachers was the way in which testing discourages them from implementing reform based teaching. I realized as I listened to the initial transcripts that I emotionally reacted to these comments with doubt and distrust. Through my reflection, I realized that I continued to hold onto my assumption that the necessity to teach in a more traditional manner in order to prepare students for a test is a

myth. While I entered into my conversations with teachers trying to acknowledge their understandings as more legitimate than my own and those of others who have interpreted teachers' beliefs and actions, I had to admit that my personal assumptions about testing and its influence on teaching were an obstacle to prioritizing the teachers' experiential knowledge over my own. My acknowledgement of this powerful assumption served as a critical factor in my subsequent conversations with teachers, the understandings that emerged from these conversations as well as my decision to dedicate so much attention to these understandings in the final narrative of my dissertation.

While the first reading illuminated my own assumptions, the second and third readings focused on highlighting the teachers' beliefs and assumptions. In the second reading, I focused on how they spoke about their personal experiences and how they shared details of their emotional responses to their experiences. Feminist research highlights that emotional and relational ways of knowing deserve more legitimacy in knowledge creation, which is integral in the relational nature of teaching (Belenky, Clinchy, Goldberger & Tarul, 1986, Noddings, 1992). The second reading played a powerful role in what aspects of my findings I chose to highlight in this dissertation. By prioritizing how the teachers connected emotionally to the topics of our conversations, I was able to highlight the aspects of our conversations that held most value for the teachers personally. Specifically, this reading highlighted the importance for the teachers of the particular lessons they designed that became the focus of much of Chapter 4. The teachers' voices changed when they spoke of these lessons. They spoke more quickly, with excitement as well as pride. I also sensed an aspect of nostalgia as it was during these experiences, that they were able to provide their students with valuable and meaningful learning experiences. The emotional intensity with

which the teachers shared their successful lessons played a crucial role in my decision to highlight examples of these lessons as a part of my dissertation. Furthermore, the intensity of the frustration and defeat within teachers' voices, as they spoke about how they feel they must teach due to the presence of high stakes tests and the stark differences between their voices as they shared details of their successful lessons and of how they teach in their tested classes was critical in my decision to focus the bulk of my dissertation on the impact of high stakes tests.

The third reading focused on how the teachers connect their experiences and their practice to the broader social, political, cultural and structural contexts of their schools. Feminist theory arose out of an interest in highlighting how women's lives and experiences are dominated by the broader social andocentric world of power and knowledge. Therefore, feminist research highlights the importance of identifying the broader contextual factors that impact individuals' experiences and actions (Fine, 1994; Wolf, 1996). The importance of highlighting these factors relates to feminist research's focus on the political nature of research and the importance of research efforts focusing on change (Cook and Fonow, 1986). This final reading helped me to illuminate that the teachers did not see their struggle with student engagement as a personal one, but more of one of a larger social issue related to the lack of attention to students needs in the creation of curricula and assessment. It also revealed how much the teachers referred to factors outside their control such as what topics are included in the mandated curriculum, the nature of questions within the end of course exams and the use of these exams to assess students, teachers and schools, as they discussed why they teach in the ways they do.

While I have described the voice-centered relational method as a tool I utilized for my data analysis, it actually served more as a tool of data awareness. Relational ontology provided a lens for me to highlight the teachers' ideas that became the focus of subsequent conversations. Therefore, while it was a valuable way to focus more attention on my own assumptions and the assumptions and connections the teachers make, it was not my primary data analysis method. My primary data analysis method was the discourse between my teachers and myself where I continuously presented how I was conceptualizing their comments and their situations and test their validity with the teachers. Through our conversations, we were able to acknowledge the factors and experiences related to the assumptions inherent in my own views as well as theirs'. Inspired by Gitlin's (1990) conception of educative research, I recognize that the teachers' comments are not a data set to be analyzed and interpreted by me, the more knowing researcher. Instead, their experiential knowledge is the most legitimate sources of knowledge, deserving of being prioritized, pursued and complexified. As Gitlin (1990) argues, "the "truthfulness" of data can no longer be understood as something extracted by an individual who uses all the appropriate techniques, but rather as a mutual process between researcher and subject, that recognizes the value of practical knowledge. The bulk of my understandings were generated during my conversations with teachers. As the teachers shared their ideas and experiences, I continuously questioned their beliefs and assumptions and exposed my own. Together, we both came to understand more about how they see their experiences being influenced by the contexts in which they work. Therefore, my voice and my evolving understandings of the challenges the teachers face were central to the creation of this dissertation.

Again, the voice centered relational method was essential in exposing assumptions and connections both the teachers and I made to our beliefs and external reality. Another central tenet of feminist research is recognizing the participants as the experts and authorities on their own experiences, who are critical thinkers holding a wealth of knowledge about their lives and the contexts in which they live them out (Wolf, 1996). It was only through extended conversations with the teachers and outside research on my own part that I came to understand that the immense impact the end of course exams has on teachers' practice is due to epistemological conflicts between how the teachers viewed valuable science knowledge in process terms while the test prioritizes factual knowledge. This understanding is crucial to understanding why the teachers felt they could not use their preferred inquiry pedagogies while also meeting the incredible demands placed on them by high stakes testing.

Data presentation details

In the following discussion, I share the reasoning behind why I chose to tell the story I did. A large aspect of my motivation in writing this dissertation was to present teachers' ideas and experiences in a clear way that reveals the dilemmas they face and how the conditions under which they teach reduce their ability to have control over their practice. Early in my conversations with teachers, I as I began to write, I realized that the value of what I had learned related not to the individual teachers' experiences and stories, but to the larger narrative of how their practice is influenced by the political contexts in which they work. Therefore, in the end, I decided that the most beneficial narrative was one that is less about the specific teachers and their specific experiences and more about the larger social issues of power and control preventing them from reaching their full capability as teachers and, thus, their ability to support such development in their students. As I shared above, I

acknowledge that the narrative of my dissertation was influenced by three main voices: the teachers, my own and that of other educational researchers and scholars. I felt that the teachers experiences and perspectives on science education reform deserved to be represented within the literature that focuses on understanding the processes of teaching and reform.

As I explained within my dissertation, this study was part of a larger personal quest that I engaged in as a science educator and educational researcher. As I shared in my methods chapter, the high school science teachers that were the focus of this study were not who I initially wanted to interview. At the beginning of my study, I did not think I had much to learn from them. I assumed that their predominantly didactic teaching styles, which I had observed as their student teaching supervisor, were a representation of their lack of understanding of the 'better' reform based methods and their lack of motivation to go beyond the easier teacher-centered methods. I did not give their explanations for why they taught as they did legitimacy. During my pilot study, I listened to the teachers voice their frustration over the factors that present such powerful restrictions on what they are able to do in their classrooms. I had to get off of my high horse and admit that my status as a PhD student does not give me legitimacy to make the claims I had been making about them and their classrooms.

My pilot study provided insight into the significant challenges the contexts of our high schools offer to reforming science teaching. Through my discussions with teachers, I was able to see how my views of science education reform were founded by the assumption that high school classrooms were places where the full implementation of reform is possible and would yield great benefits for both teachers and their students. The strength of my belief

came at the disregard of the obstacles our schools currently present to supporting the learning and growth of both students and teachers. Seeing science education reform through the teachers' eyes also made me question the authority of the scholars whose interpretations of teachers' classroom practice and critiques of their practice had fueled my own views. I am afraid science teacher educators and researchers, including myself, have failed to acknowledge how the contexts of schools influence and limit the potential teachers have to implement reform-based instruction. In reflection, I realize that I designed much of my writing as a conversation to other researchers whose beliefs and assumptions aligned with those I had before my conversations with teachers. Thus, the final story of my dissertation was in reaction to the work which came before mine which I felt presented an unfair and inaccurate portrayal of science education reform (Mauthner & Doucet, 1998).

My dissertation focused on telling the teacher's side of the story which has been previously silenced by the interpretations of researchers (including my unenlightened self). For example, there are very few reports of successful science teaching within the traditional contexts of public high school science classrooms as teachers' teaching consistently fails to measure up the standards set by the researchers who assume the privilege to determine the definition of success. My dissertation highlights the lessons that the teachers described as successful, using their definitions of success. I chose to present their successful lessons in detail because I recognize that they represent models of inquiry based teaching within the current contexts of high school science classrooms, which are lacking within the literature on reform. The fuel behind my motivation to pursue this study and present my findings in the way I did comes from my sense of care and admiration for the teachers. I am humbled by their strength as I admit that I would have quit a long time ago had I faced the challenges and

disrespect they do on a daily basis. Therefore, my role as a researcher incorporates a sense of advocacy for teachers, illuminating their struggles while also acknowledging their triumph and celebrating their accomplishments.

My decision to focus so much of my dissertation on the specific details of how the pressures of high stakes testing influences teachers' practice is also related to the disregard researchers have granted to the influence of high stakes testing on teachers' practice and reform. As I explained above, I continued to hold doubt about teachers' connections between testing and didactic teaching which became clear as I focused on my emotional reactions to the teachers' comments. Since I found myself questioning the teachers' impression of the impact of testing on their practice, a main goal for my second conversations with teachers was to understand how they make this connection. Through my questioning and their explanation and reflections, I came to see the misalignment of the types of understandings the test prioritizes to those students gain through the teachers' inquiry based lessons in their non-tested classes. I also pursued more data, seeking out examples of test questions to make sure that my readers would understand. I chose to present what I learned in a story of teacher decision making, revealing the complexity of the dilemma the teachers faced. Through this story, I specifically address what I suspected other educators and researchers likely believe.

Through my presentation of David's dilemma over how to teach genetics, my story is grounded at the level of practical decisions in practice, highlighting the nature of the dilemma the teachers face and how their ultimate decisions have less to do with their own beliefs about good science teaching and their goals for students and more to do with the constraints placed on them by mandated curricula and high stakes testing. My intention was not to codify, name and describe the teachers experiences within the language and themes

already established in the literature. Instead, my goal was to act more as a storyteller, that highlights the complexity of the situation teachers face, exposing the coherent whole of the teachers' experiences and actions (Polkinghorne, 1997).

Another benefit of telling the storied account is that it helps us move toward a solution, which brings me to the final and most important motivation I had for how I presented the data in the way I did; my interest in producing a work that has the most potential to foster change. By illuminating the injustice of testing, I am hopeful that my research can play a role in efforts committed to reversing accountability policies and granting teachers more autonomy. My desire to present the teachers' story was fueled by the impact the teachers' emotions had on me as they shared the reality of how testing impedes their ability to focus their teaching on their students' interests and needs, separating their classroom actions from their care and concern for their students. Since teachers feel no choice but to conform their actions in ways that meet the demands of those who have power over them, high stakes testing currently operates as a tool of subordination and injustice. I am dedicated to producing future articles that focus on illuminating the injustice and tragic consequences of high stakes testing.

Conclusion

The driving motivation behind this dissertation was both personal and political. My goal was to illuminate the broader contextual challenges that have received little attention within the literature. My goal was also personal as I strove to leave behind my previous disregard of teachers' perspectives. Because my focus was on conveying previously silenced voices, my research was inspired by feminist epistemology and feminist research theory. Furthermore, since my study focused on illuminating how the teachers' practice is influenced

by the broader social, structural and cultural contexts in which they teach which is why the voice-centered relational method was invaluable for my data analysis.

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